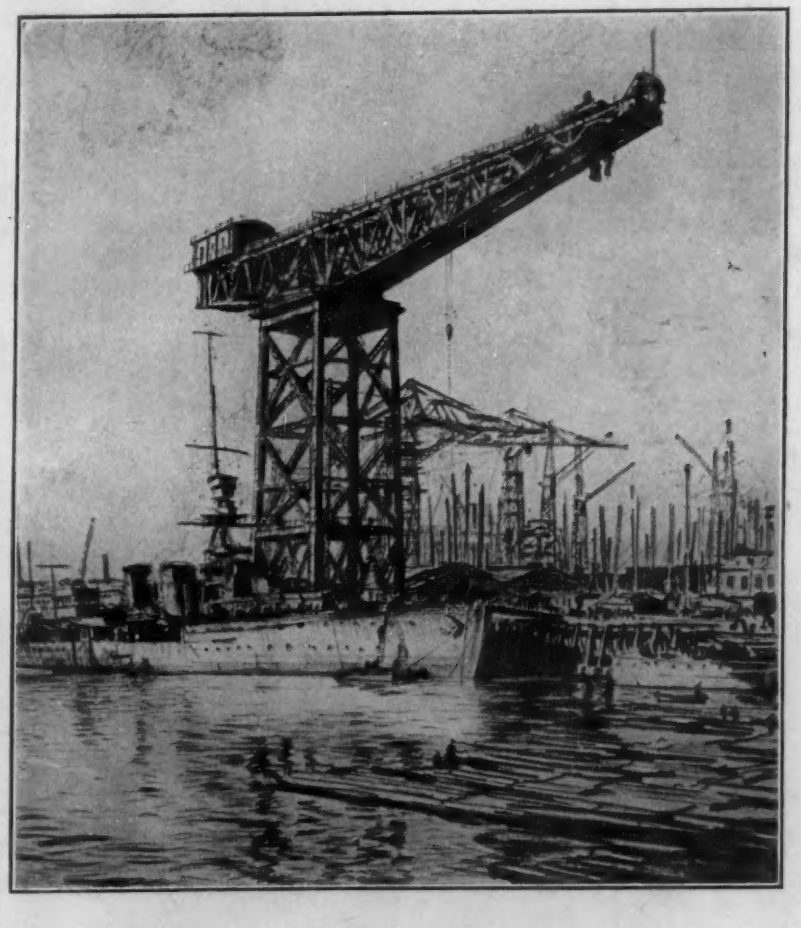
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

JAN 19 1927

VOL. VII, No. 5 NOVEMBER, 1926



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WHEN you stop to think about it, this metal, lead, is an astonishing element. It isn't satisfied with taking an essential part in practically every industry, or with protecting buildings against deterioration, or with any number of other jobs of major importance. Lead has one ambition in life—to make itself useful to everybody—and it has succeeded admirably.

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With lead glass lenses in his eyeglasses the man whose eyes are misbehaving sees as well as anybody.

And the sparkling crystal brilliance of cut glass on the tables of particular hostesses is a pleasing, every-day evidence of the service lead performs in glass.

Amazing, the varieties of uses for lead. But the productive research of the Eagle-Picher institution is constantly on the watch for new uses for lead in all its useful forms. Tomorrow, when industry's developing processes require new services from lead, Eagle-Picher will be ready to supply the need.

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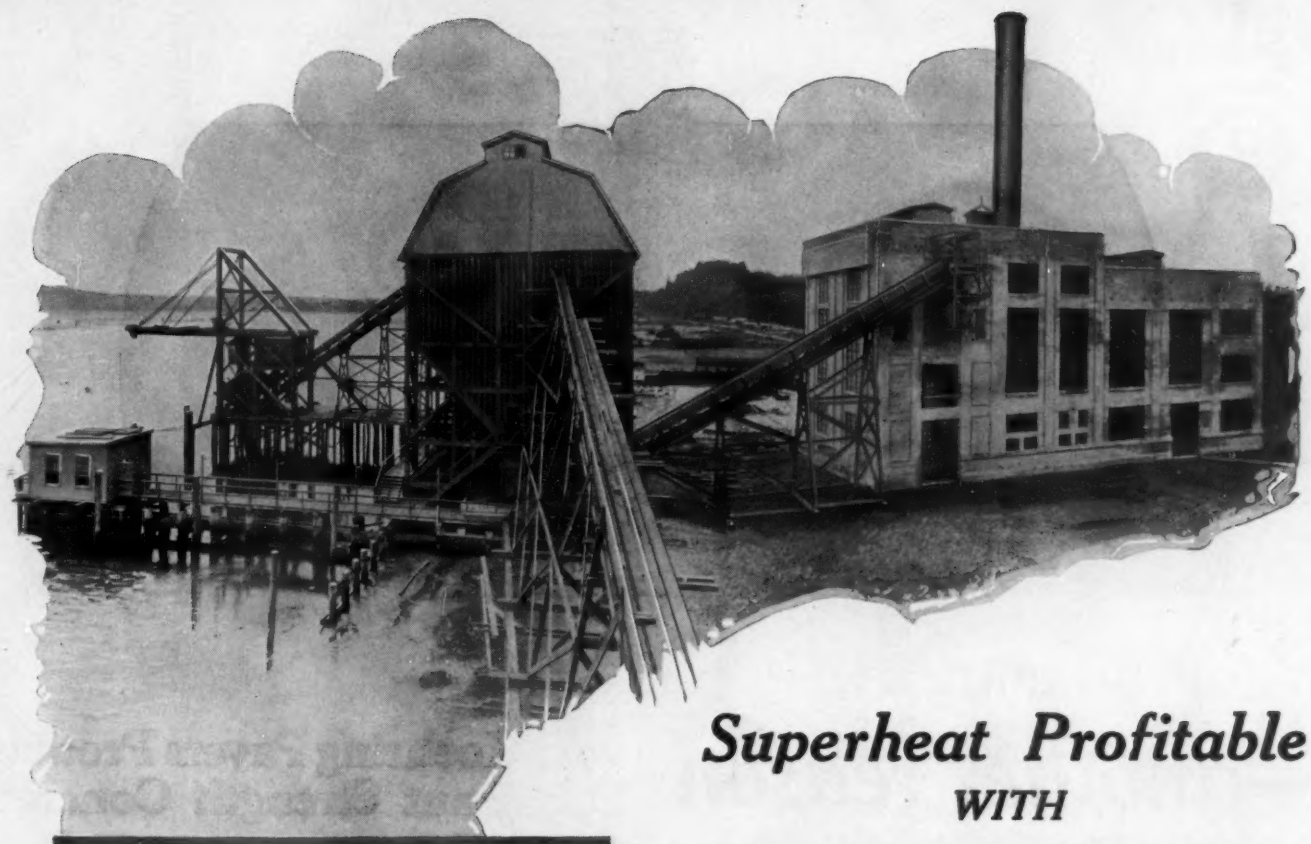

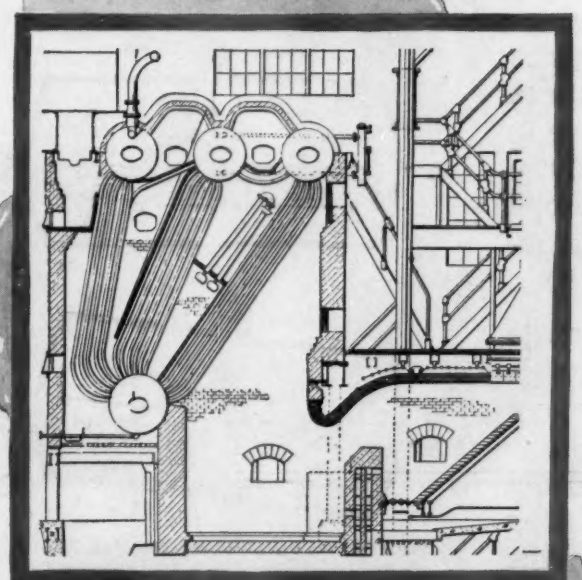

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The 6250 kva. plant of the Mountain States Power Co. at Coos Bay, Oregon burns refuse wood from the large lumber mills which it supplies with power.

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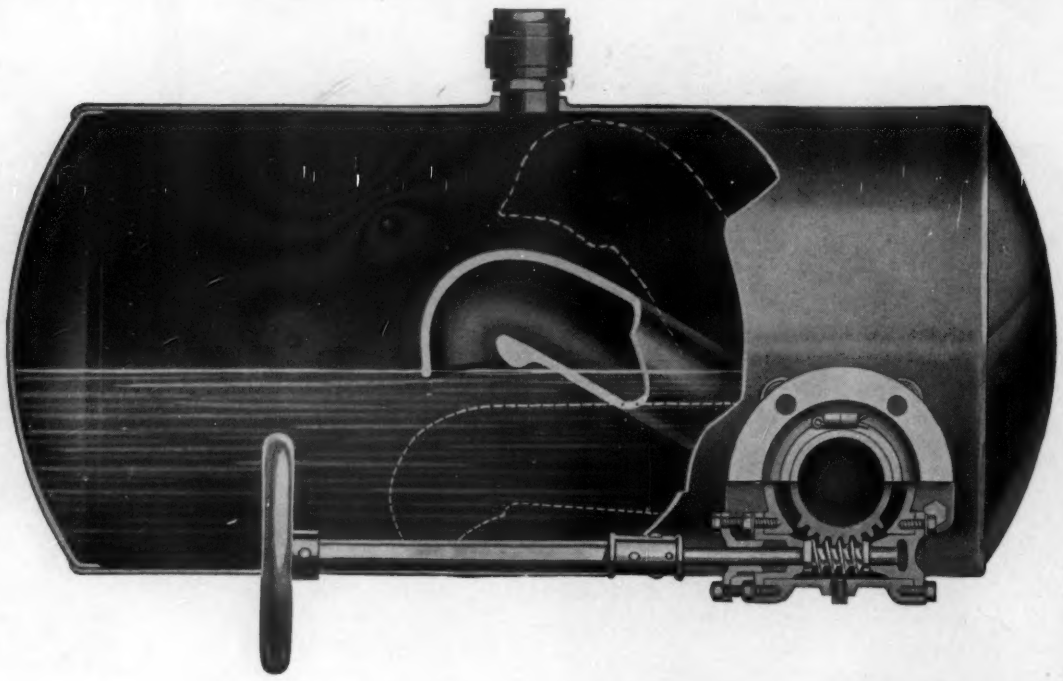


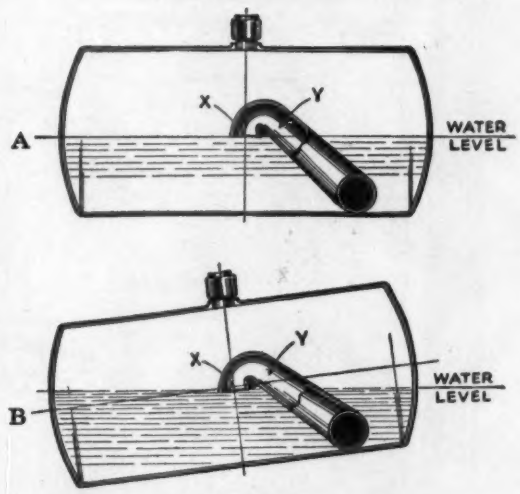
—another reason why Koehring Pavers Produce Dominant Strength Concrete

VITALLY important to the resultant strength and durability of concrete is the admittance of an accurate amount of water into the mixing drum at exactly the right instant. Long ago the Koehring Company recognized this fundamental requirement and set to work to devise an automatic water measuring system.

Today, the system is as nearly exact and accurate as human ingenuity has been able to design. A balanced three-way valve is automatically opened at a certain point, by the charging skip as it is raised, admitting the water into the mixing drum at exactly the right instant. The regulating hand wheel governs to a minute accuracy the amount of water which is to be used per batch.

All dribble is eliminated by the syphon-gravity principle which draws the water through a straight 3½ inch pipe into the mixing drum. Straight flow from the tank to drum secures a fast, clean discharge.

This is another pioneering development by Koehring engineers which with the Koehring batch meter, Koehring boom and bucket, and Koehring five action remixing principle produces standardized, dominant strength concrete of unvarying uniformity.



A and B illustrate clearly why changes of grade do not materially affect the accuracy of water measuring when using the Koehring system. X represents the volumetric center of the tank and Y the measuring arm.

"Concrete—Its Manufacture and Use" is a 210 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.

KOEHRING COMPANY
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MANUFACTURERS OF PAVERS, MIXERS—GASOLINE SHOVELS, CRANES AND DRAGLINES

The pneumatic Paving Breaker does the work of 15 hand laborers.

Evolution of the Ditch-Digger

Some years ago, when little boys used to yell "Get a horse" at the hesitant and asthmatic vehicle which was the ancestor of the modern automobile, the term *ditch-digger* identified the man who had to perform the hardest labor imaginable. Squads of these workmen would be in the street with their crowbars and hammers, and there was always the sound of metal ringing on metal as the ponderous hammers descended. The passers-by would wonder that no hand was crushed in the process.

That was before the development of the Paving Breaker. Work that fifteen men took a day to perform is now accomplished by one man. Compressed Air has supplanted the uncertain human muscle, and the ditch-digger is no longer the man but the machine.

In this instance, as in a hundred others, Ingersoll-Rand Company has enlisted the aid of Compressed Air in the elimination of wasted time and effort.

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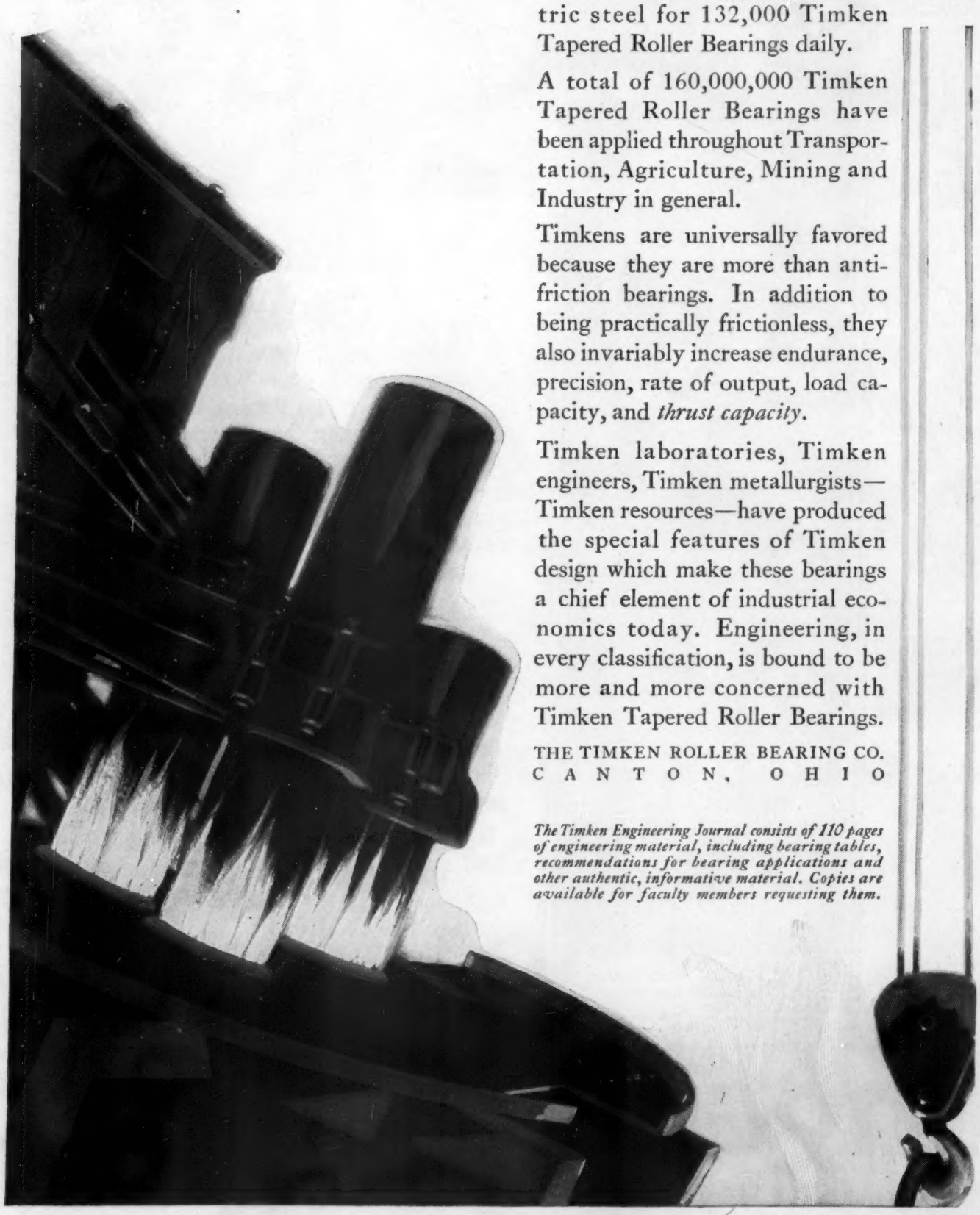

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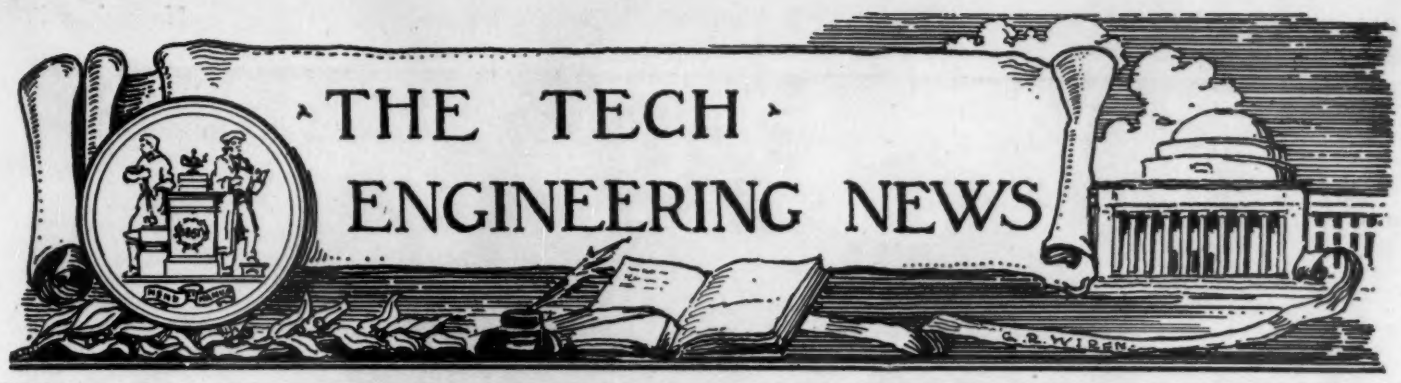

Volume VII CAMBRIDGE, MASS., NOVEMBER, 1926 Number 5

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Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergradutes.

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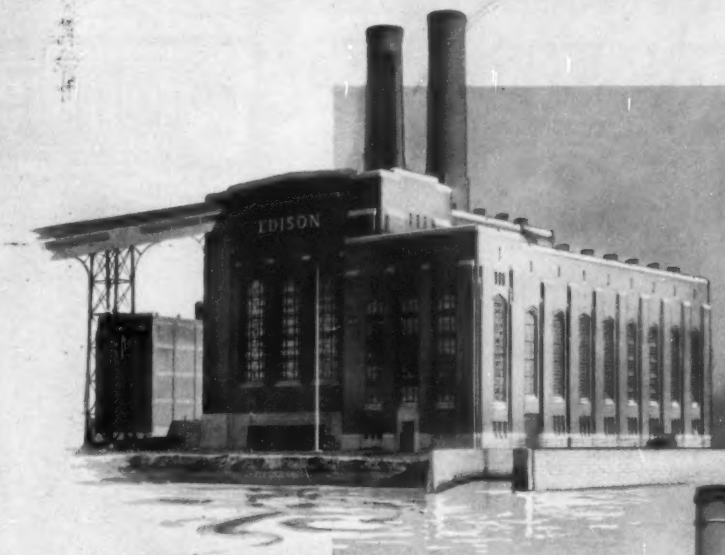

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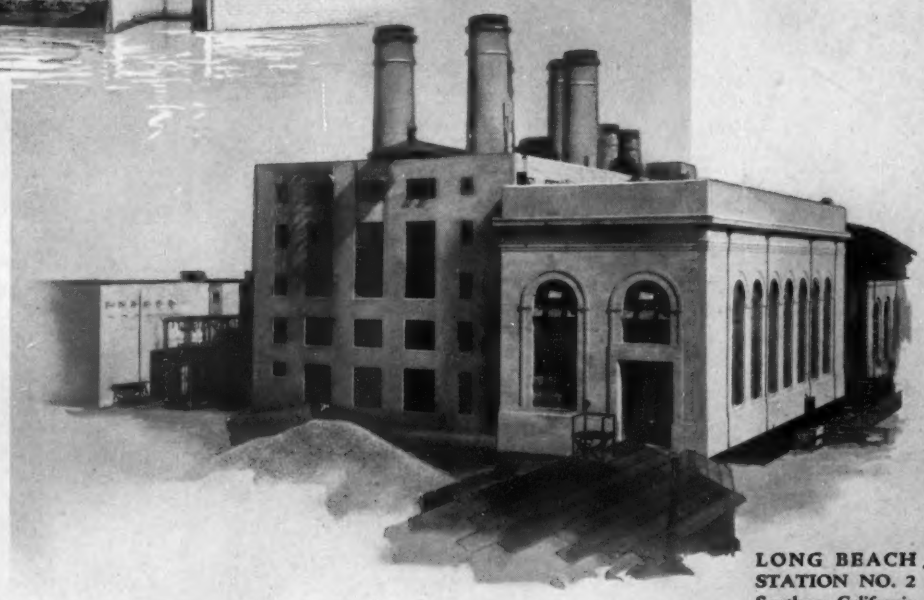

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VII — NOVEMBER, 1926 — NUMBER 5

The Engineer in Export Business

A brief but interesting paper on an unusual phase of graduate activity

By AUBREY P. AMES, '19

China Department, Standard Oil Company of New York

MADE IN THE U. S. A.—These words and scores of familiar trade marks greet the American traveller in all parts of the world—convincing evidence that even the broad expanse of the United States is not sufficient to confine the activities of our restless industry. American motor cars make the Oriental coolie jump for his life as they do the natives of Broadway or the Loop. Whether the highway is a trail through tropical jungles, an open reach across the African desert, or the gay Champs-Elysées, these ubiquitous vehicles are always to the fore. American electrical machinery lights cities in remote corners of China or Brazil, while rails and locomotives from our smoky steel centers bring these remote towns into touch with the outside world. The American typewriter makes itself heard even in the Government offices of a great European industrial nation. "Kodak" is without doubt one of the most widely understood words of any language.

Back in earlier days our clipper ships cruised to all corners of the globe, returning with cargoes of spices, silks, and manufactured goods for the consumption of a growing young country. Then these renowned sailors disappeared from the high seas and for over fifty years we attended closely to home affairs, which resulted in the development of a new commercial and financial giant among nations. Now, we find ourselves reaching out beyond the home borders again, this time with our own manufactured goods to sell. The Stars and Stripes have once more appeared on the high seas, carried by squadrons of modern steel freighters and luxurious passenger liners, so that we are prepared to support our foreign sales activities with our own delivery organization.

Where does the engineer fit into this comparatively new game of export trade?

The recent establishment of a new course in Ship Operation at M. I. T. marks a long forward stride toward putting engineers into the delivery end of foreign trade. Rapid expansion of our merchant marine since the World War has made it necessary for ship operators to build their personnel largely from untrained and inexperienced material. Numerous and expensive mistakes have been made, in both engineering and commercial phases of operation. Great progress has been made but there is room for more, and shipping operators are certain to look with favor upon the new M. I. T. course which promises a supply of men trained to fill positions in this young and growing branch of American commerce.

In general our foreign sales organizations have been built up in the same haphazard manner as those of the shipping concerns. Since men with training and experience in foreign marketing were practically unavailable, it was necessary to take the best material to be had and build from the ground up. However, the star salesman who is selected because of an excellent record in domestic markets may or may not prove to be a success when put on his own resources in a strange land. Likewise, the technical expert who has ready solutions for home territory problems may find it extremely difficult to get out of his well-worn groove and cope with new situations which export trade produces in great variety. Under this trial-and-error system the more adaptable eventually qualify, while the others drop out and return to their old ruts. At best, it is a slow and expensive method of building up an export sales organization.

Broadly Trained Men Sought

Among the more progressive export firms there is an ever increasing tendency toward the selection of university and engineering school graduates for positions on foreign staff. It has become quite generally recognized that such men are not only well equipped as to all-around education, but have to a considerable degree the mental and social adaptability so highly important in dealing with foreign peoples. Having these primary qualifications, the "hand picked" man is able to round out his required special training and experience with a minimum of lost time and expensive mistakes.

The obvious line of endeavor for an engineer going into foreign trade is that of machinery and allied products. Exporters of these products have hardly made a beginning in the survey of prospective markets and the adaption of their lines to the special requirements of each market. There is also great need of development in follow-up service, by means of which the foreign buyer is properly instructed in the use and maintenance of his purchase. Success or failure of engineering products in foreign

(Continued on page 248)

FIG. 4

X-ray diffraction pattern of powdered sample showing comparison of standard pyrite (above) with sample of supposed marcasite (below). The comparison indicates the sample to have been really pyrite, in spite of its external form

X-Ray Spectroscopy

The second article of the series explaining the use of the x-radiation in identifying substances

By JOHN T. NORTON, '18

Assistant Professor of Physics,
Massachusetts Institute of Technology

THERE are a great many methods in use at the present time by means of which the presence of a substance may be indicated or its nature identified. All of these methods depend upon the development of some observable property of the substance which will be definitely characteristic of that substance alone. The success of the method depends upon how completely the particular property is characteristic and how readily it may be developed to an observable degree. It is the purpose of this paper to describe some of the ways in which X-rays may be used in this direction, and to indicate the sort of problem to the solution of which these methods may be applied.

The methods to be described are essentially spectroscopic ones, that is, they employ the apparatus and technique of X-ray spectroscopy so that they are in many respects laboratory methods, but they are quite capable of development along lines of routine procedure so that they may be useful to the research worker in the industrial research laboratory as well as the worker in the fields of pure science. There are three classes of properties which are useful for purposes of investigation and these are the characteristic emission spectra, the characteristic absorption spectra, and the diffraction spectra. The emission and absorption spectra are essentially atomic properties and do not depend upon the way the atoms are put together so that the indications of these methods of identification will be independent of the physical or chemical state of the substance. The phenomena of the diffraction spectra are dependent entirely upon the way in which atoms are arranged with respect to one another. This arrangement is characteristic in the case of the various types of crystals and is very useful in the study of this important class of atomic aggregates.

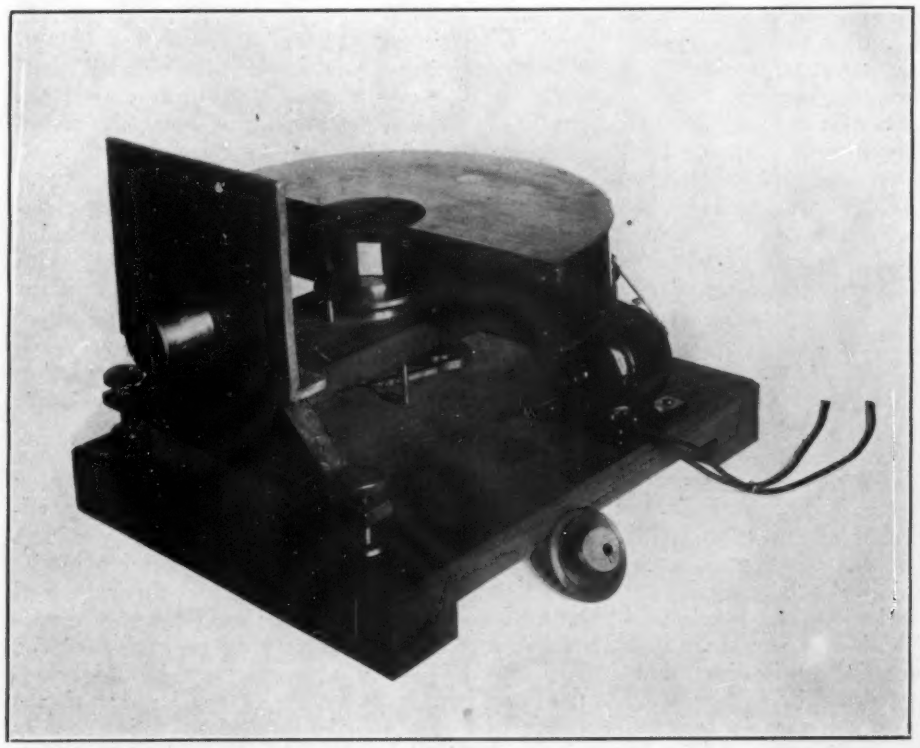

FIG. 1

X-Ray spectrograph showing the system of slits; the oscillating holder for the crystal, and the curve of cassette for the film

When the atoms of a substance are bombarded by a stream of electrons or cathode rays, the atoms are caused to emit X-rays of certain definite wavelengths. It has been predicted by theory and proven by experiment that the wavelengths of these rays are definitely characteristic of the atoms being bombarded, and that the wavelengths change in a regular and simple fashion as we pass from one element to another. Thus, if there is a device for resolving the beam from such a target into its various component wavelengths and for measuring the wavelengths themselves either directly or by comparison with a standard, the atoms of the target material may be identified. Such a device is the X-ray spectrograph, and a simple form of this instrument of the writer's design is shown in Figure 1. It con-

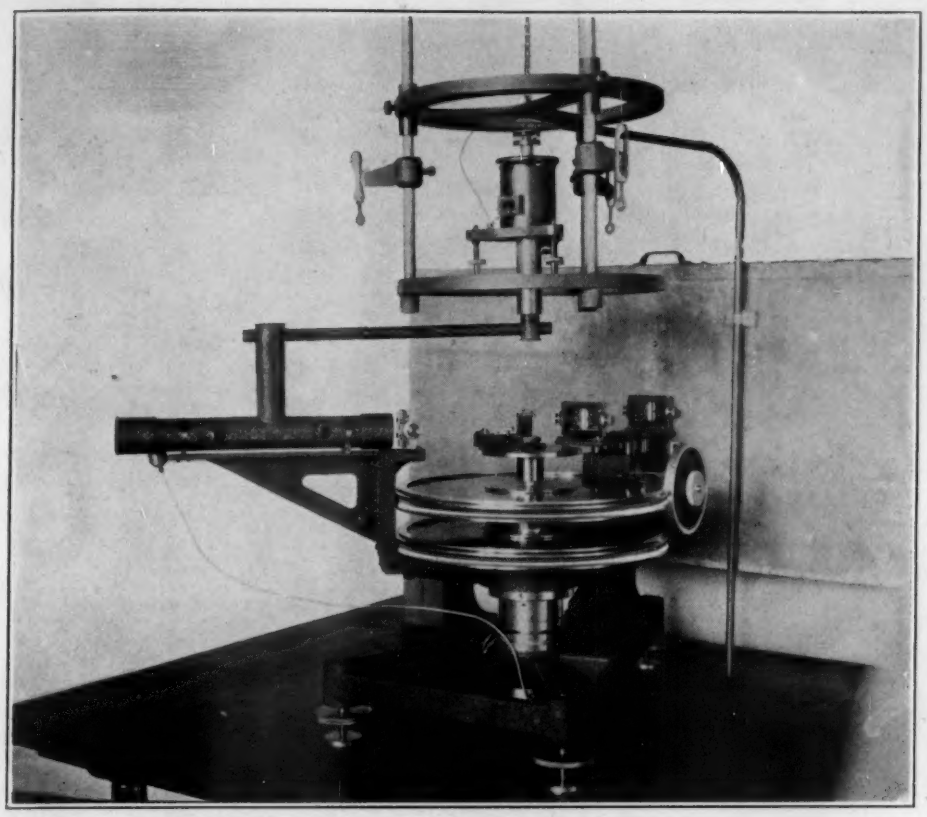

FIG. 3. X-RAY SPECTROMETER

This instrument is capable of measuring the angles of X-ray reflection with a high degree of precision

sists of three essential parts, the slit system which defines the X-ray beam coming from the substance to be examined, the rotating crystal which is used to separate the various wavelengths, and the photographic film upon which these wavelengths are recorded. The cleavage face of a crystal such as rock salt or calcite will reflect X-rays, but each wavelength at a different angle so that by a measurement of the angle of reflection, the wavelength may be calculated. The characteristic radiation consists of a few discrete wavelengths, and if the radiation falls upon a very slowly turning crystal, each will be reflected in turn, and a photographic film bent around the arc of a circle about the crystal will record these wavelengths as a series of bright narrow lines. Some other element on the target surface would give similar lines in a slightly different position, and if both were present, both sets of lines would appear. For purposes of identification, the spectral film of the unknown is compared with similar films of known substances until all the lines have been accounted for. It is necessary, in order that the determination shall be complete, that all of the lines are accounted for because there is, of course, a reason for the appearance of every line. Figure 2 shows the appearance of some of the more prominent lines from the element molybdenum, as obtained with the apparatus of Figure 1. In cases where it is desired to measure the wavelengths more accurately than is possible with the simple spectrograph, a more elaborate instrument is employed. Such an instrument, which is in use in the author's laboratory, is shown in Figure 3, and is capable of quite high precision. For most work of identification, however, the accuracy of the simple spectrograph suffices.

In order to examine a material by this method, it is necessary to place it on the target of the X-ray tube. Because of the intense heating caused by the electron bombardment, the material must have a rather high melting point, and should not be volatile so as to impair the vacuum of the tube. Substances of this sort are the metals, oxides, silicates, carbides, etc. The X-ray tube is best made with a removable target, and if a metal is to be examined, it may be in the form of a sheet soldered to the surface. In the case of a powder, the target surface, usually copper, is roughened and the powder rubbed thoroughly into it. In all cases the target should be carefully water-cooled.

One of the chief disadvantages of the method is that it excludes a lot of materials which cannot be used inside the evacuated tube. This disadvantage has largely been eliminated by the development of a tube which will produce high speed cathode rays outside of the tube. This is the work of Dr. W. D. Coolidge, M. I. T. '96, who is well-known because of his development of the X-ray tube which is now used almost universally. With this new device, any material, be it a gas, liquid or solid, may be mounted in the path of the rays emerging from the thin metal window of the cathode ray tube, and the characteristic X-rays which result may be studied as before with the spectrograph. This is a very important development and has been brought about only within the last year.

The absorption of X-rays by a body is an atomic phenomenon, and is explainable in a quite simple manner by our modern ideas of atomic structure. If we investigate the variation of the absorption as the wavelength is changed, it is found that at certain wavelengths the amount of the absorption undergoes a very sudden change. The wavelength of this change is characteristic of the absorbing element, and may be used to identify it. This wavelength is meas-

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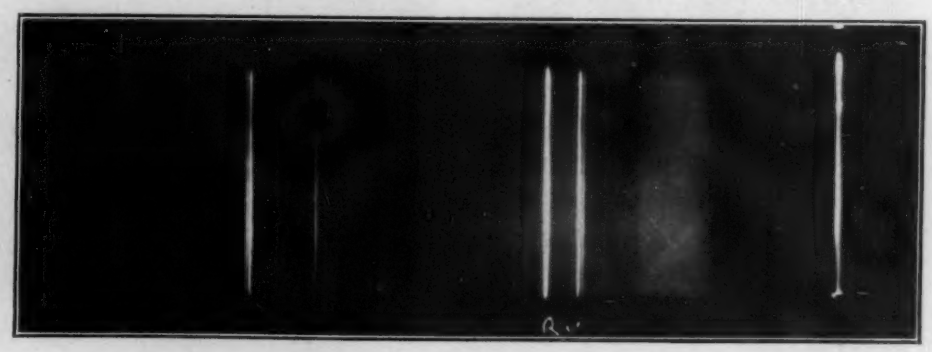
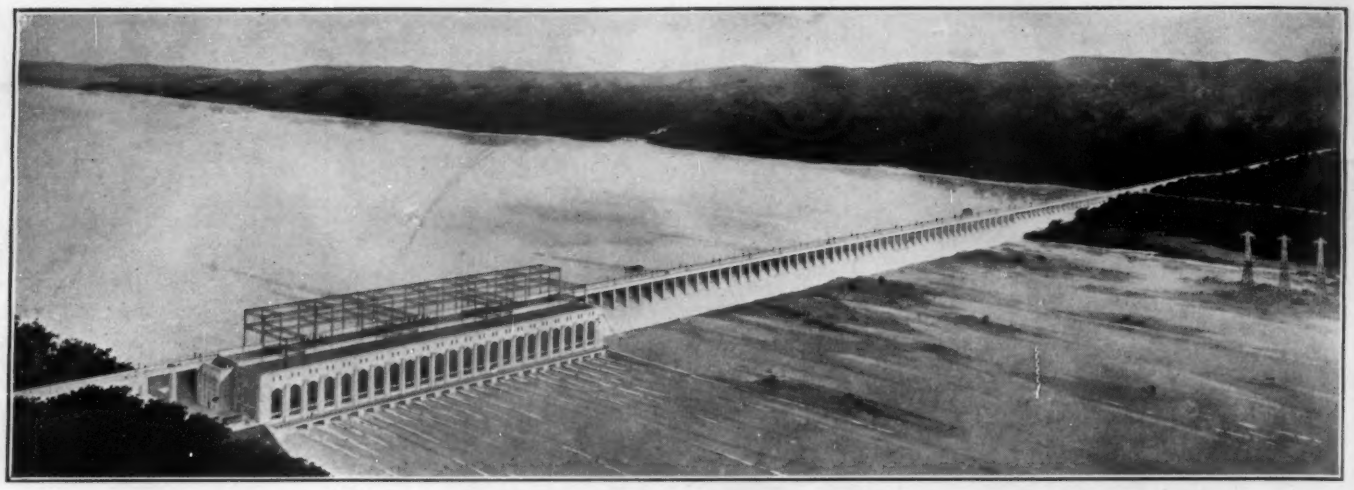


FIG. 2

X-ray spectrum of molybdenum showing the "k-series" lines and the absorption edges of silver ruthenium and bromine



Conowingo

A description of the second largest single hydroelectric installation in the United States

By G. R. STRANDBERG
Assistant to the Chief Hydraulic Engineer, Stone and Webster, Inc.

THE hydroelectric project now under construction on the Susquehanna River near Conowingo, Maryland, by The Philadelphia Electric Company, through its subsidiary Philadelphia Electric Power Company, and the latter's Maryland subsidiary, The Susquehanna Power Company, will be the largest single hydroelectric installation in the United States with the exception of that at Niagara Falls.

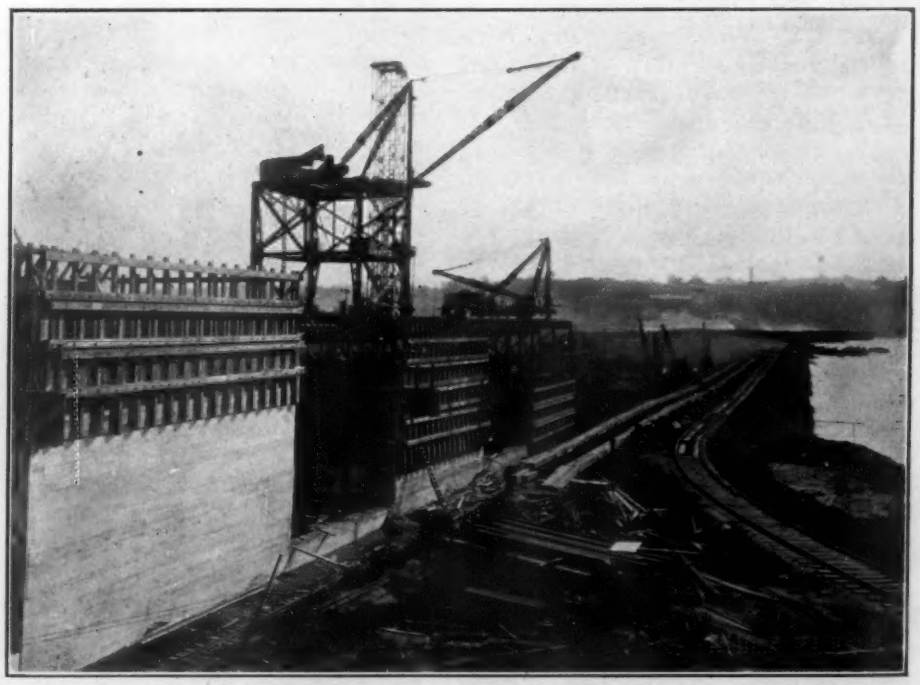
The dam and power house will be located in the State of Maryland about 4 miles above tidewater, and the upstream half of the reservoir will be in Pennsylvania. Before construction could be started it was therefore necessary to obtain the joint approval of the Public Service Commissions of Maryland and Pennsylvania, and as the Susquehanna River has been declared a navigable river by the War Department, a license from the Federal Power Commission was also required.

The station will have an initial installed capacity of 378,000 h. p. and an ultimate capacity of about 600,000 h. p. The initial output at Conowingo is estimated to be about 1,380,000,000 kw-hr. in an average year. The electric energy will be generated at 13,800 volts and transformed to 220,000 volts at the power station for transmission to Philadelphia, about 70 miles away.

The dam, of which the power station headworks will form the westerly part, will be of concrete of the gravity type, founded on bedrock at an average elevation about 15 ft. above sea level. The dam will have an overall length of about 4800 ft. with a non-overflow section about 1200 ft. long at the east end and one about 275 ft. long at the west end, a power station 950 ft. long at the west shore, and a gate controlled spillway section 2385 ft. long across the bed of the river. To prevent upward pressure under the dam foundation, grout holes about 30 ft. deep are being provided on 10-ft. centers near the upstream face. A continuous drain, located about 10 ft. from the upstream face, is being installed along the foundation under the entire length of the dam to carry away seepage from the foundations. This drain is connected to transverse drains leading to the downstream face every 45 ft. Contraction joints in the dam are sealed with copper sheets, bent Z shape.

The normal and maximum pond level above the dam will be maintained at Elev. 108.5 ft. which level was fixed by agreement with the Pennsylvania Water & Power Company. At this elevation the water will be backed up somewhat over an undeveloped portion of the tailrace of the latter company's Holtwood plant.

The reservoir will also flood out the present Conowingo bridge on the main Philadelphia-Baltimore highway



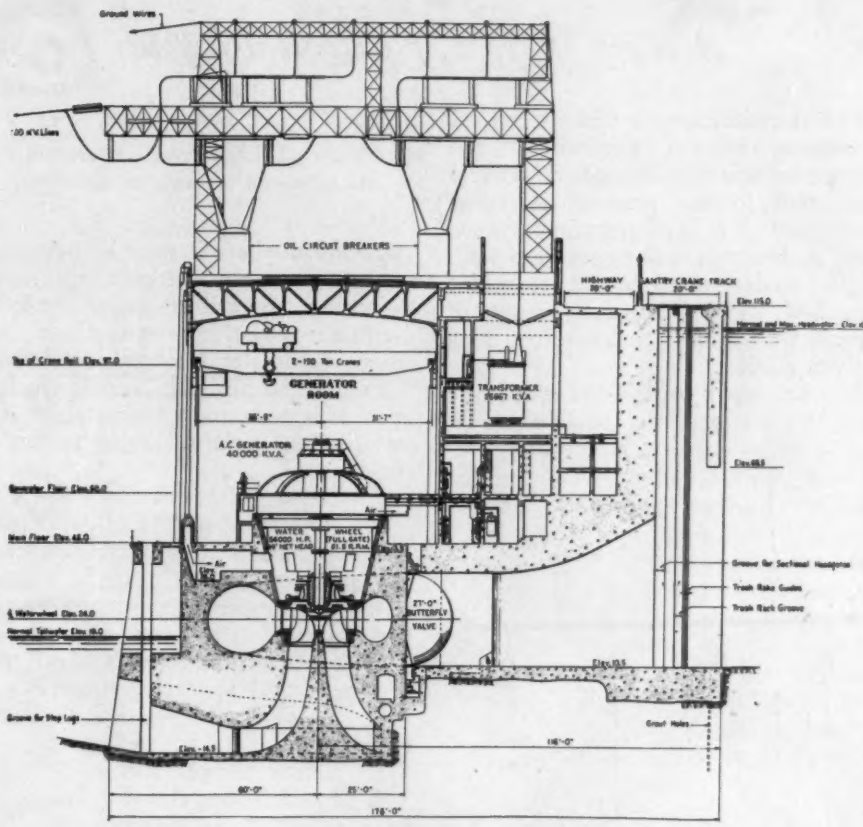
THE CONSTRUCTION WORK IN PROGRESS
View of part of the work, showing the method of handling the concrete by traveling towers on the construction trestle

as well as several miles of the tracks of the Columbia & Port Deposit Branch of The Pennsylvania Railroad. The Conowingo bridge is being replaced by a new concrete bridge, combined with and supported by the dam. Several miles of new approach road will also be constructed to connect the new bridge with the main highway. To replace the flooded tracks of the Pennsylvania Railroad 17 miles of new railroad is being constructed from Port Deposit to Fishing Creek.

The spillway section of the dam is of the conventional ogee type, having a parabolic crest and a circular curved section as it approaches the apron. It is designed to pass a flood of 880,000 c.f.s. including the flow through the seven units, and will have a fixed crest at Elev. 86.0 ft. The flood flows over the spillway will be controlled by fifty structural steel crest gates and three regulating gates. The crest gates will be of the stoney type, each 22 1/2 ft. high and 40 ft. span and weighing about 42 tons. The crest gates and regulating gates will be made tight at the sides by means of vertical rubber covered staunching rods. The bottom seal will be made by contact between a timber bottom member and a steel beam sill in the concrete. Each regulating gate will be 10 ft. high with a 40 ft. span, and of the roller type. One service gate, the same size as the crest gates, will be provided for inspection and repairs to the crest gates, slots for this gate being provided in the piers just upstream from the main gates.

Three electrically operated traveling gantry cranes, each equipped with two 30-ton main hoists, mounted on a single trolley and operated by the same motor, will be used to operate the crest and regulating gates as well as trash racks and sectional head gates at the intake. These gantry cranes will have a hoisting speed of 10 ft. per minute and a travel speed of 300 ft. per minute. They will be operated on a runway provided on the top of the dam and over the intake section of the power station. A gasoline engine driven generator will be installed on one crane for emergency use.

To handle the crest gates the cranes will be equipped with special lifting beams. As these lifting beams are never submerged, each one will be arranged for an operator to ride on it and operate the locking device which attaches it to the gates. When the gates are raised to their open position they will be held in place by means of pawls engaging suitable stops on



THE COMPLETED STATION

A cross-sectional view of the station and dam as it will look when finished

the ends of the gates, thus permitting the crane to be moved to another gate. A special lifting beam will also be provided for handling the sectional head gates and trash racks.

The general layout of the power station was determined upon after careful study of the many requirements for an economical station. The distance center to center of the units was determined by the length of station required for the electrical bay and for the switching structure and outgoing transmission lines on the roof as well as by the design of the scroll cases and the intake areas for the water wheel units.

There will be seven main units and two small station service units in the initial power station installation. Provision is also being made for extension to the power station for four additional main units.

The intake structures had to be designed to give an economical entrance for the water as well as to give protection from ice in winter. The most economical form of protection from ice was determined to be a curtain wall extending to a depth of 40 ft. below the normal pond surface and located at the upstream face of the intake.

The entrance to the waterways of the turbines will be located at the bottom of the reservoir and each waterway will be divided into two parts for a distance of about 50 ft. downstream from the entrance, where the two parts will be merged into one.

In each intake opening and a sufficient distance behind the ice protection wall to permit the operation of a mechanical rack rake, will be located a set of trash racks, made up in panels of convenient size for handling, and installed in guides in the concrete. The lower panels will be equipped with round edge flat steel bars spaced 6 in. center to center for the main units and 2 in. center to center for the station service units. The upper panels, which will be located behind the curtain wall and therefore will be of little use in providing actual waterway area, will be faced with treated timber to decrease the adherence of ice to the racks at the water surface and also to reduce the cost of the panels.

The rack sections have been designed for an unbalanced head of 10 ft. over their entire area, under which condition the maximum stress in the steel will not exceed the elastic limit.

Downstream from the racks and adjacent to the entrance to the main waterways of the turbines, will be located guides for sectional head gates which will be made of structural steel in panels of such a size that six of

(Continued on page 236)

Hydro-Electric Stations

A study of types of electrical layouts for hydro-electric stations

By JAY BALSBAUGH, '24
Electrical Engineering Department,
Massachusetts Institute of Technology

The electrical layout of an electrical generating station determines the relative location of the power control equipment in the plan of electrical connections. It is of great importance since it determines the operating flexibility under normal and transient conditions and the continuity of service which may be expected from a given station.

In the study of the plan of the electrical layout for a particular station it must be recognized that an individual station cannot be considered by itself in determining the type of

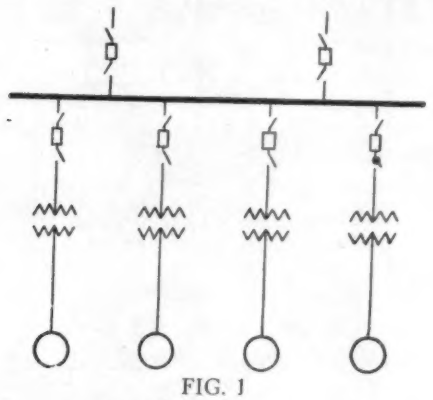


FIG. 1

layout warranted. Other factors such as the character of the load served, the location and distribution of the load relative to the station and the relation of the station to the remainder of the system to which it is connected must also be considered.

The types of switching equipment which are available for performing switching operations are plain disconnecting switches, air-brake disconnecting switches and oil circuit breakers. The application of the plain disconnecting switch is limited to the isolation of apparatus for cleaning and repair work. A more distinguishing and appropriate term for such switches would be isolating instead of disconnecting. The air break disconnecting switches find their application primarily in high tension circuits where it is desirable to carry on switching operations with greater rapidity than is possible with plain disconnecting switches and where it is desirable to eliminate the high cost of high potential oil circuit breakers. These switches may be either manually or electrically operated and have a small rupturing capacity as may be required for the magnetizing current of transformers, charging current of short transmission lines and light load currents. Oil circuit breakers have their application where it may be necessary to rupture large currents, to permit switching operations under load, to facilitate switching operations and where automatic features are desired.

In determining the layout which is applicable to a particular station it is necessary that the following factors be considered.

1. Degree of continuity of service.
2. Parallel operation of generators.
3. Flexibility in performing switching operations.
4. Limitations of damage resulting from failures or incorrect operation.
5. Stability under transient disturbances and operating conditions.
6. Simplicity in physical layout of equipment.
7. Safety of operators.
8. Facilities for cleaning and repair work.
9. Relation to remainder of system.

The degree of continuity of service should be commensurate with the type of load served and the importance of the station with respect to the remaining generating system. If the station in question represents an unimportant part of a large system and if the station can be shut down for a relatively short time without materially effecting the remaining stations then an inexpensive plan of switching layout could be used. However, if a base load station is considered the investment involved in obtaining every assurance against an interruption of service would be justifiable. While the difference in initial cost between a simple plan of electrical layout and an extensive plan is very great, still the relative portion of this cost to the total station cost is quite small. Also while the cost of an oil circuit breaker is a relatively large item, its cost in proportion to the generator, transformer or transmission lines which it protects is quite small. Consequently it could be considered sound engineering to jeopardize the operation of such equipment for a small saving in switching layout.

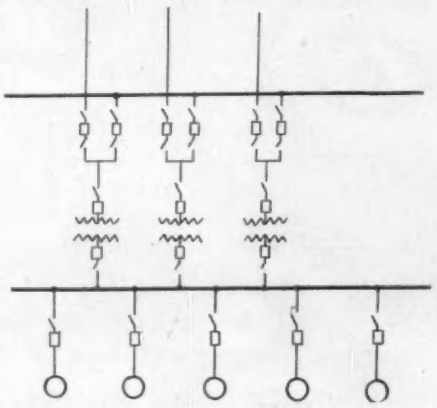


FIG. 2

It is in general necessary to provide for parallel operation in an electric generating station in order to make possible the economies resulting from large scale production and also to more stabilize the power. However parallel operation also presents difficulties in that it increases the short

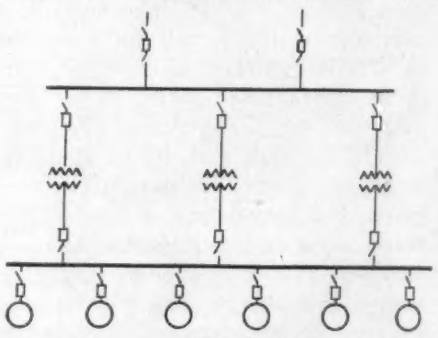


FIG. 3

circuit current which may be fed into a failure, thereby increasing the thermal and magnetic stresses on the equipment and requiring larger rupturing capacity breakers. Also parallel operations will make the effect of a failure felt over a greater portion of the system. In order to protect the apparatus against very heavy short circuit currents and to protect the service by maintaining voltage it is usually necessary to install external reactance in large systems. This reactance may be located in the generator leads, busbars or feeders. The application of reactance is usually limited to the low potential circuits since it is in the low potential circuit that the larger currents are present and due to the much greater cost of reactance for high potential circuits. Reactances are usually spoken of as "current limiting reactances," although they may just as appropriately be termed "voltage maintaining reactances." That is, as a current limiting device their function is one of protection of the equipment against short circuit stresses and as a voltage maintaining device the protection of service by maintaining the voltage on all feeders as high as possible. Reactance located at various places in a

system will have widely different effects on current limitation and voltage maintenance and it is necessary to make very thorough studies as to its relative effects and also its possible effect on the transfer of power under normal operating conditions.

When the electric power is transmitted at voltages higher than it is considered economical or practical to wind the generators, the type of electrical layout will in general fall under one of three types determined, in general, as to whether there is to be a low or high tension paralleling bus or both. The three types are,

1. Generator and transformer switched as a unit.
2. Generators, transformers and lines switched independently of each other.
3. Transformer and line switched as a unit.

Layouts exemplifying the above are given in Figs 1, 2 and 3. The condition in which the generator and transformer are switched as a unit has the advantage of eliminating a low tension paralleling bus with its concomitant trouble of heavy short circuit current and the necessity for reactors. Also in this case it is possible to energize a transformer by slowly building up the generator voltage, thus saving the necessity of switching a transformer on the line at full voltage. It has the disadvantage that a failure or repair work on any transformer or generator eliminates from service the corresponding generator or transformer, and the capacities of the generators and transformers are the same.

With a common low and high tension bus, that is when generators, transformers and line may be switched independently, the advantages are that the respective ratings of any type of equipment need bear any relation to any other equipment, and all equipment is interchangeable with regard to its operation. The disadvantage is that a greater amount of swiching equipment will be required than if either a low tension or high tension paralleling bus were used. However this greater amount of switching equipment gives more operating flexibility, which in many cases is warranted.

The elimination of the high tension paralleling bus has the advantage of reducing the number of high tension breakers required and permits the greater portion of the switching to be done at the low potential. Also the switching surges on the high voltage side are reduced. The disadvantages are that with line and transformer operated as a unit a failure of either will remove from service the corresponding unit and the capacities are necessarily the same.

In general it may be said that elimination of a paralleling high tension bus promotes a better electrical isolation of the apparatus. That is, a

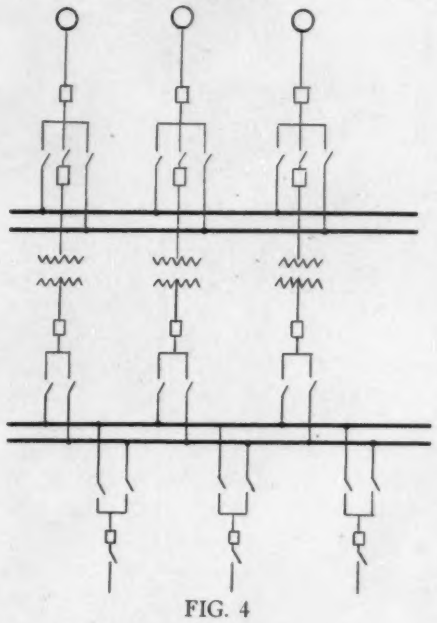


FIG. 4

failure on any line or transformer under this condition will have less effect on the operation of the system than with all outgoing lines paralleled. With all outgoing lines paralleled a failure external to the station will reduce the voltage on all lines very materially and thereby cause a discontinuance of service on all lines. By tieing all high tension lines together it is possible to use balanced protection for the lines thereby simplifying the relay protection and obtaining better discrimination between lines and better selective operation of the relays under all operating conditions. It may also be pointed out

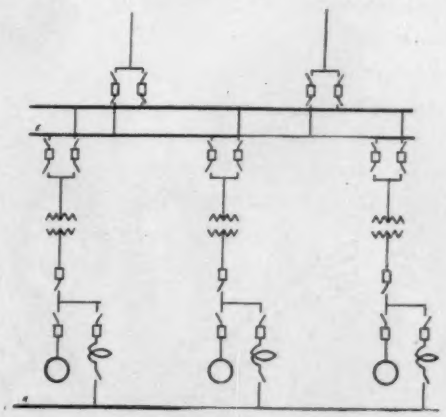


FIG. 5

here that by far the greater number of failures occur external to generating stations or substations and consequently any plan that provides against external failures and simplifies switching and control of the outgoing circuits is of great importance. Electrical failures within the station are a possible contingency and must be provided for as the effect of an internal failure are usually more severe and more widespread in its effect than external failures.

The foregoing gives in general the factors which are of importance in making the electrical layout of a given station, it is now desirable that some layouts be studied. Fig. 1 shows a very simple form of station layout with very little switching equipment. In this case each generator is directly connected to its corresponding transformer so that there is not any low tension switching equipment required. Aside from the fact that the generators or transformers are not interchangeable, a failure on the high tension bus will cause a complete shut down of the plant. Also a failure or necessity for repair of any oil circuit breaker will require that circuit to be taken off the line. This layout finds its application for small plants where the investment must be held to a minimum at the sacrifice of maintenance of service and operating flexibility.

The layout in Fig. 2 shows that the high tension lines are not rigidly connected to the high tension bus and therefore a transformer and a line can be operated as a unit in event of a failure on the high tension bus. It may be noted that the relation between generator, transformer and line capacity need not bear any definite relation to one another. This layout represents better operating flexibility and service continuity than Fig. 1.

The layout in Fig. 3 shows a paralleling high and low tension but presents no greater assurance against a shut down than do either Figs. 1 or 2. The layout in Fig. 4 shows double high and low tension buses and thus is safeguarded against a failure of any single bus. In this case the generators can be operated directly connected to transformers without being paralleled on the low tension bus, the low tension buses being regarded as a transfer bus for allowing any generator to be operated with any transformer. Parallel operation can be effected on either the low or high tension side as desired. This layout represents a maximum in assurance against shut down for a given expenditure for switching material but it is not very flexible as regards switching under changing load conditions. That is, it is impossible to transfer loads by the disconnecting switches.

(Continued on page 248)

The Pictorial Section

A description of the more important units of hydroelectric installations

Within the past century a great change has taken place in the economic structure of society. This change may be ascribed to the ever increasing use of machinery and power. The waterfall and wheel was one of the first sources of power. Many of the New England mill towns grew on the banks of streams capable of producing power.

Economists speak of cities on the fall line meaning cities near a source of water power. In spite of the importance of water power, the larger part of our power is still produced from coal. Using a source such as Niagara Falls was out of the question until high tension transmission was developed. At the present time electrical energy can be transmitted long distances under very high voltages and the trend is towards still higher voltage on the line. The whole question of power is one of great concern to all engineers as our present system is extremely inefficient. Coal is mined from a mine and transported to the place where power is wanted. This involves a deal of work and many people suggest the conversion of the latent heat of the coal to electrical energy at the mine. This is not very practical as a steam power plant must be near a large body of water to provide for the condensers. In time, however, the coal will be carried to large central stations close to the mines and accessible to water. These central stations will probably be coordinated with the hydroelectric developments into a super-power system.

With these facts in mind, it seems well to devote one of our pictorial sections to a description of some of the equipment used in typical hydroelectric stations.

Fig. 1 show a shop assembly of one of the turbines before shipment. These units are the highest powered hydraulic prime movers ever constructed. The turbines are of the vertical shaft, single-runner type and are each designed to deliver 70,000 horse power when operating under the net effective head of 213.5 feet at the 25 cycle speed of 107.1 R.P.M. The generators are directly connected to the vertical turbine shafts. The turbine casings are of the volute type and built of cast steel with an intake diameter of 14'-0". The water enters the casing and is uniformly distributed around the outer periphery of the turbine runners. The water is discharged from the runners in a vertical direction and is carried off to the tail race through concrete draft tubes.

Referring to Fig. 1 it will be noticed that each turbine casing is made up of a number of sections having both transverse and longitudinal joints. Certain sections on the inner diameter of the volute contain stay vanes, designed to withstand the internal hydrostatic pressure and to conform in shape with the direction of flow from the casing to the movable guide vanes. This type of construction is known as the "Taylor Sectionalized design." Fig. 5 shows a turbine runner for one of these units. The runners are of cast steel and built with an overall diameter of approximately 15'-5". Each runner weighs 112,000 lbs. The runner is of the mixed flow Francis type cast in one piece. Fig. 8 shows one of the Johnson penstock valves in use at this plant. The valves are hydraulically operated and may be opened or closed by exhausting or admitting pressure to the small annular space surrounding the cylindrical valve plunger. This type of valve is particularly desirable for hydroelectric installations of this nature in view of the simplicity of operation, the tightness against leakage when closed and the cylindrical construction which permits of their use under extremely high head conditions. Fig. 12 is another volute casing for a 45,000 H.P. turbine designed to operate under a head of 145 feet at 120 R.P.M.

The section of the casing is reduced as the flow advances, giving the water a higher velocity. This is done to counteract the effects of friction and provide an equal velocity on all parts of the runner. Fig. 2 is a very interesting view of the auxiliary control pumps at the La Gabelle project in Canada. These pumps are placed below the generator level and control the operation of the turbines. They are designed to keep the turbines running at a constant speed regardless of the load. Fig. 11 is a view of the generator room in the new twin cities' plant of the Ford Motor Co. This plant is located on the Mississippi River. It is of interest as one of the latest power plants employing both steam and hydraulic energy. Fig. 6 shows an automatic hydroelectric station of the Otter Tail Power Co., Fergus Falls, Minn. This station automatically starts and stops itself depending on the load and the water supply. It is coming into extensive use in out of the way places where it would be difficult to maintain a large engineering force at all times. Fig. 4 is a view of the older horizontal units in use at Niagara. Most of the newer developments use a vertical unit. Fig. 7 is a typical installation and is of general interest. It shows the general layout of the generator with the exciter mounted on top of the generator and driven by the same shaft. This exciter provides direct current for the fields of the generator.

Fig. 3 shows the unit installed in the new Baker River development. This is a horizontal unit. Fig. 10 shows the draft tube of the Queenstown Chippewa development in Canada. The draft tube is built of concrete and provides a base for mounting the generators and turbines. Fig. 9 is a view of the penstock of a similar development. The penstocks are large steel pipes riveted at the joints and suitably calked. After the pipe is in place, it is buried in concrete which takes the strain off the pipe and prevents any motion.

These few views give one a fair idea of the trend in hydroelectric developments. It behooves us to see that further use is made of this potential source of power so as to conserve our fuel supplies and secure cheaper power from our industries.

Adam K. Strickler, Jr., '29.

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FIG. 1
TURBINE FOR NIAGARA

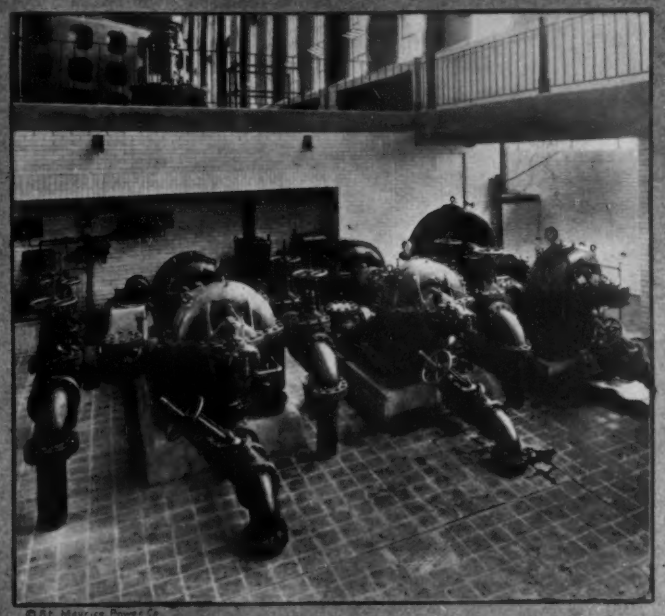

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FIG. 2
GOVERNOR PUMPS

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FIG. 3
BAKER RIVER INSTALLATION

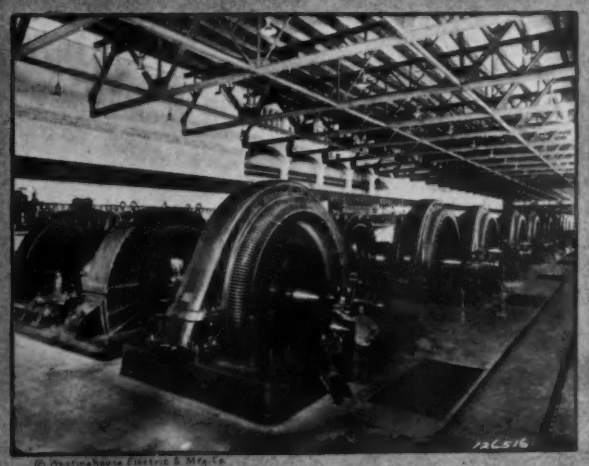

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FIG. 4
NIAGARA HORIZONTAL UNITS

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FIG. 5
RUNNER FOR TURBINE UNIT

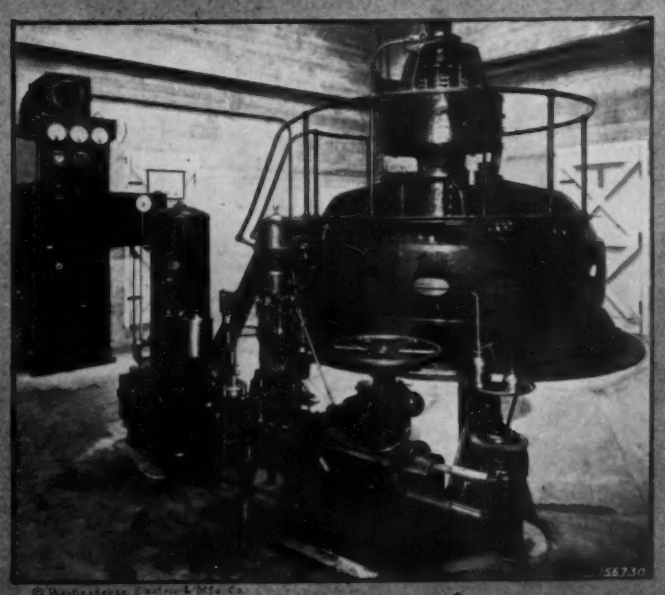

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FIG. 6
AUTOMATIC POWER STATION

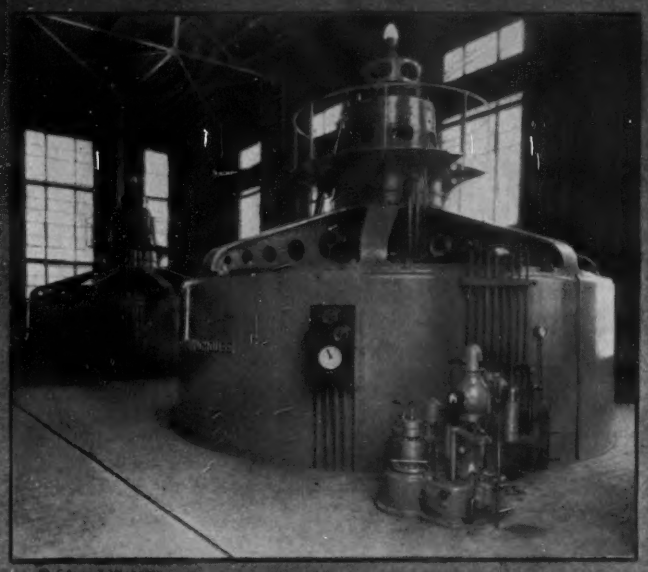


FIG. 7
BARTLETTS FERRY GENERATORS

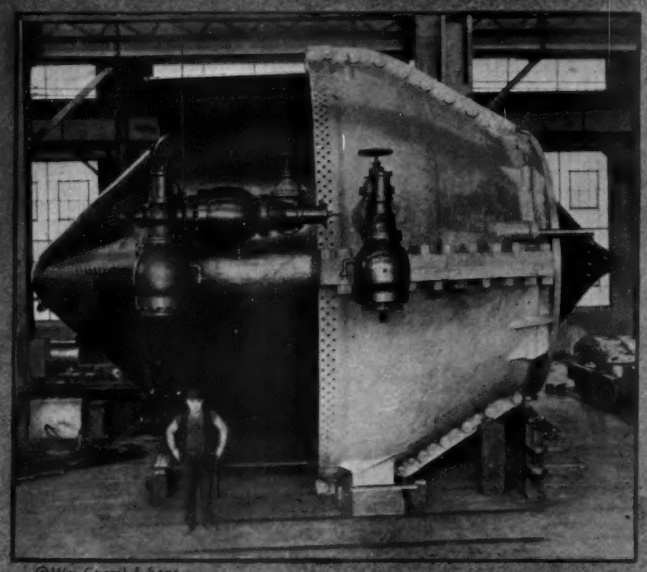


FIG. 8
JOHNSON PENSTOCK VALVE

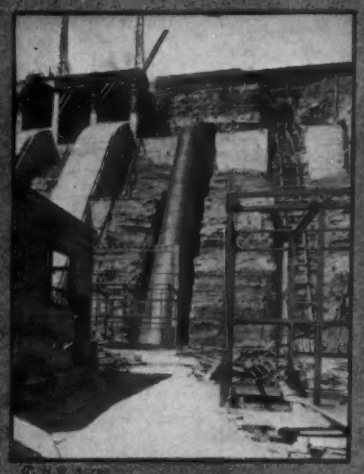


FIG. 9
PENSTOCK
CONSTRUCTION

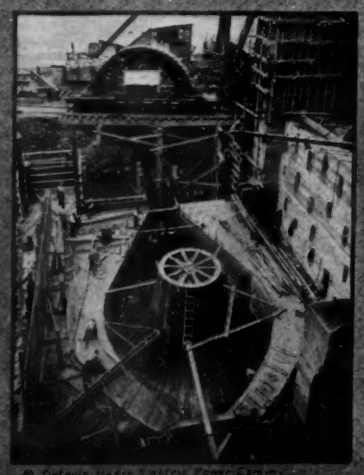


FIG. 10
DRAFT TUBE
CONSTRUCTION

FIG. 11
GENERATORS AT TWIN CITIES

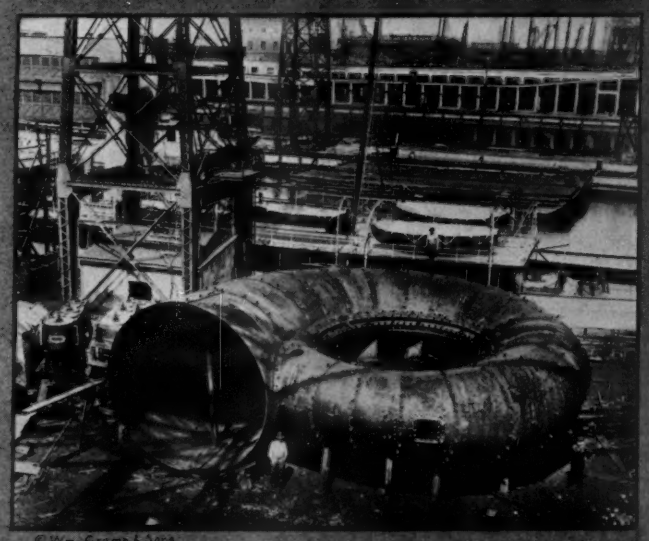


FIG. 12
VOLUTE TURBINE CASING

Departmental Notes

PROFESSOR C. M. SPOFFORD

CIVIL ENGINEERING

The United States Bureau of Public Roads has recently decided to enter into an agreement with the Institute for experimental work to be conducted in the Laboratory of Soil Mechanics recently established by the Civil Engineering Department, under the supervision of Dr. Charles Terzaghi, Associate Professor of Foundation Engineering. The purpose of this coöperation, as stated by the Chief of the Bureau, is to secure and develop facts and information which will define the governing principles and advance the science of highway improvement for the immediate practical application of the expenditure of the very large sums of public moneys now being made available for highway improvement purposes. The immediate purpose of the agreement is to study the influence of accidental factors on the results of standard tests for subgrade investigations and to investigate the possibility of improving testing methods. The Bureau is planning to provide a research assistant, who will be assigned to the work in the laboratory, and to use from its regular forces such other assistants as may be necessary to coöperate with the Institute staff in supervising the conduct of investigations, and also to furnish, at its own expense, such machinery, apparatus and equipment as may be mutually agreed upon for use in these investigations.

During the last summer, the department established a permanent base line, 2.2 kilometers in length, at Camp Technology, the length being determined by Invar tape measurements to an accuracy (probable error) of one part in eleven hundred thousand. A primary triangle of the United States Coast & Geodetic Survey in the vicinity of East Machias was connected to this base line by angular measurements made by the new Hildebrand theodolite recently acquired by the department, this instrument permitting the reading of angles to seconds and being the most precise type of instrument yet developed for the field measurement of angles. Repetition of the various angular measurements of the primary triangles from time to time, combined with new determinations of the length of the base line, will enable the securing of valuable and precise information upon what, if any, lateral movements may be occurring in the earth's crust in the vicinity of East Machias. This work will supplement work of similar character now being carried on in various portions of the world.

An appropriation has been made for the establishment of a permanent bench mark near the Institute buildings in Cambridge, in order that changes in level of the ground surface in this section of Cambridge may be accurately determined. The bench mark will go to bedrock at a depth of more than 100 ft. below the surface, and observations will be made on it from time to time by students and members of the department.

Reports from the class of 1925, received in the fall of that year, show the average compensation of the Civil and Sanitary Engineering graduates of that class to be $145.00 per month.

An interesting statistical study giving the occupation of graduates of the Civil and Sanitary Engineering Department from the years 1868 to 1925 was recently made in connection with the preparation of a Department Bulletin which was published last June. The results of this study are shown in the following table:

Occupations of Graduates of the Civil and Sanitary Engineering Courses

Engaged in Professional Engineering, In Independent Practice or with Engineering Firms	269	
With Federal and State Engineering Forces	101	
Railway Engineering (or Operation)	85	
Structural Engineering	79	
Engineering Teachers	70	
Municipal Engineering	58	
Sanitary Engineering	56	
Highway Engineering	44	
United States Army Engineer Corps	35	
Hydraulic Engineering (General)	34	
Hydro-Electric Engineering	25	
United States Navy Civil Engineer Corps	9	
		865
Engaged in Construction Work with Contractors and Construction Companies, Presumably Acting in Engineering Capacities	138	
Engaged with Business Firms, Presumably Acting in Engineering Capacities	176	
		314
Engaged in Manufacturing	134	
United States Army or Navy other than Engineer Corps	27	
Bankers and Brokers	23	
Miscellaneous	121	
No information available	252	
		557
Total		1736

It will be noted that of the 1736 graduates during that time now living, 50% are engaged in professional engineering and 12 1-2% are with contractors, construction companies, and business firms, presumably acting in an engineering capacity. These figures indicate the tendency of the graduates of Civil and Sanitary Engineering to continue, after graduation, along the lines taken by them while students.

C. M. SPOFFORD

PROFESSOR E. F. MILLER

MECHANICAL ENGINEERING

The Mechanical Engineering Department has been very active during the last few months. New courses of instruction, both graduate and undergraduate, have been added, new equipment has been installed and research of far reaching importance has been carried out.

The new subjects are four in number, two to be given by Prof. R. H. Smith and two by Prof Earl Buckingham. The new subjects given by Prof. Smith are for the Senior Class students of Mechanical Engineering and graduate students of Automobile Engineering. These courses, Production Methods and Manufacturing Processes are to make students as thoroughly familiar as possible with the mass production methods used by the leading industries.

There are two other new courses, Course 2.858, Inspection Methods,

30-30 is a study of the principles of shop inspection including shop measurements, measuring instruments and gages, tolerances, dimensional standardization, calibration of shop standards, and analysis of production problems by means of measurement, is a 2d term-4th year Elective. Course 2.99, Metrology and Dimensional Engineering Standardization, 45-90, includes first, a study of fundamental units of measure, measuring systems, and calibration of standards; second, the purpose of measurements in scientific and research work, engineering and general use; third, a study of conventional measuring instruments, their characteristics and methods of calibration; fourth, accuracy of measurements; fifth, analysis of measurements; sixth, shop measurements and analysis by means of measurement; seventh, dimensional engineering standardization; and eighth, inspection engineering. It is a 1st term, graduate study. Both of these are to be given by Prof. Buckingham, who is one of the best experts in the country on Metrology and Dimensional Engineering Standardization. Professor Buckingham has been since December of last year a member of the staff of the Mechanical Engineering Department.

New equipment has been added to the Steam Laboratory, Testing Materials Laboratory and the Machine Tool Laboratory. The Steam Laboratory has now a representative steam engine of each type since the installation of a Unaflow Engine. It is equipped with a friction brake for test purposes. Students in the Steam Laboratory may now become familiar with the theory and actual operation of steam engines of all types.

The Testing Materials Laboratory has received its share of new equipment. In the Heat Treatment Laboratory there have been placed a new Electric Heat Treating Furnace and an Automatic Carbonizing Machine. A Motor Generator Set has been installed to furnish current allowing efficient use of the furnace obtained through the courtesy of the General Electric Co. The furnace has a temperature range up through 1800°F and has a hearth 15″x15″x24″ making it suitable for giving instruction in practical shop heat treatment, and for extended research. The American Gas Furnace Company's Automatic Carbonizing Machine is of sufficient size to allow instruction in production methods used in commercial work, and should be very valuable for research.

A hand power Hydraulic Pump of 10,000 lbs. per sq. in. capacity has been added to the Testing Materials Laboratory equipment. This pump is mounted in a manner that will allow it to be easily moved to the testing machines and will be valuable in general pressure testing and for research in problems requiring fluid pressure.

A small but very practical Ransom Concrete Mixer has been added to the equipment of the Concrete Laboratory. It will be used in class work and will allow the students to gain some experience in a practical concrete mixing operation. The mixer will be used in conjunction with modern measuring apparatus including an inundator for sand. It is to be hoped that this small unit will be useful in general research work in concrete.

This new feature section we believe to be worthy of the cooperation of all of the various departments of the Institute. We want to present in these columns authentic statements signed by the department heads rather than the garbled ideas of youthful reporters. We feel that there is a very real need for this type of information and are devoting a comparatively large amount of space to it in this initial attempt in an effort to bring it forcibly to our readers' attention. We will appreciate any criticisms the presentation make evoke.

The personal equation has proved troublesome in testing cement and sand. An instrument has been devised at the Bureau of Standards that will allow all tension Briquettes to be fabricated under uniform pressure, regardless of the person doing the work. One of these instruments has been ordered for the Testing Materials Laboratory and should greatly increase the value of student work where the personal equation of the inexperienced operator introduces very large errors. It will also allow any inexperienced operator to do much better research work.

A Repeated Stress Testing Machine will be added shortly to the Laboratory equipment. This machine will be used to illustrate the making of repeated stress tests, and should be valuable for Research work along these lines.

Research work of great importance is being done in the department on the influence of elasticity and errors in tooth shape on stresses in gears, which is being carried out under the direction of Professor Buckingham, using a Lewis gear testing machine.

E. F. Miller

PROFESSOR S. C. PRESCOTT

DEPARTMENT OF BIOLOGY AND PUBLIC HEALTH

Professors Prescott, Bunker and Slack have, during the summer participated in a cooperative investigation of a new process for the treatment of milk by electricity. The new process appears to leave the milk in a perfectly normal condition except for the destruction of a large number of bacteria including any types of pathogenic bacteria which may have gained access to it. The other laboratories cooperating in this investigation were, the Bacteriology Departments of the New York State Veterinary College at Cornell, and the Michigan State College. Investigations in this subject are being continued.

Dr. R. P. Bigelow spent the summer at the Marine Biological Laboratory at Woods Hole where he was engaged in describing the collection of Stomatopod Crustacea made by the Steamer Albatross under the direction of Alexander Agassiz. These specimens were collected in Samoa and other Islands of the Southern Pacific a number of years ago.

Professor C. E. Turner has been engaged to develop a plan for the training in Personal Hygiene and Health Habits in the public schools of Cleveland. Professor Turner is one of the foremost workers in the field of training specialists in this particular branch of health instruction, and this is the first opportunity which has been offered to anyone to put into effect in a community of a million people the technique which he has worked out experimentally at the Institute and in neighboring cities.

Mr. C. H. Blake is engaged in a research on the identification of Crustacea taken by the Mount Desert Biological Survey during the past summer. This is a general survey of the marine waters around Mount Desert Island, Maine. Mr. Blake's findings may have much economic interest,

since among the animals which he is studying are found forms which serve as food for fish, others which are enemies of fish, and still others which seem to act as scavengers.

In Biochemistry special research is being carried out by Dr. Anderson, a research assistant added to the Department this year. Important research is also being done in the field of industrial bacteriology and food technology.

S. C. Prescott

PROFESSOR C. L. NORTON

DEPARTMENT OF PHYSICS

The custom of securing additional lecturers from outside the Institute has been continued in the Department of Physics this year. Among those who have recently lectured or who will soon come to the Department are Dr. H. Weyl, of the Federal Polytechnical Institute, Zurich, Switzerland; Dr. C. G. Abbott of the Smithsonian Institute; Professor A. Joffe of the University of Leningrad; and Professor Bragg of the University of Manchester, England.

Several changes in methods of instruction in first and second year Physics have been made which, it is hoped, will increase the efficiency of the teaching. There has been a redistribution of the hours devoted to lecture and recitation, and a period of supervised study has been introduced in place of one of the lectures. In the first year Mechanics Laboratory, an extensive duplication of the apparatus has been carried out so that we more nearly approach the ideal condition of having lectures, recitations and laboratory experiments all devoted to the same subjects at the same time. While this considerably increases the cost of equipment, it makes for efficiency in instruction and economy of staff. The notes have been revised and rewritten by Professors Drisko, Page and Young. Special provision has now been made for the college transfer men of the first and second year which enables them to adjust their schedules in Physics in line with ours with much less lost motion than heretofore.

Aside from the regular work of instruction and research which has been going on steadily in the laboratories, considerable new and interesting work has been begun.

Professor Wilkes is carrying on an investigation of the thermal conductivity of a number of building materials which are being widely used in an attempt to cut down the heat losses from dwellings. An extensive study of the thermal conductivity of metals, particularly alloy steels is going on. The results of these investigations are of increasing importance in the design of internal combustion engines, economizers and air pre-heaters. Recently a long investigation of the physical properties of refractory substances were completed, the results of which are being adopted by both manufacturers and users as a basis for standard specifications. Further research along this line for the manufacturers is being planned. An investigation of the relation of time, temperature, and depth of case hardening in a gas carbonizing furnace is being carried out. A lengthy investigation leading to a precise determination of the specific heats of refractory oxides at high temperatures is underway.

The long investigation carried on by Professor C. L. Norton upon the physical properties of silica refractories has been completed and the results presented at a recent meeting of the Physics Colloquium. As a result of this work all the large silica plants in the country are being converted from hand to machine operation with a great improvement in the quality of the product.

The laboratory of optics and photography has been over-hauled during the year to make a much more convenient set-up of the experiments to provide for additions of apparatus. A number of research problems are being worked upon by Professor Hardy and his associates, the outstanding one, the definite measurements and specification of color. The industries producing paper, fabrics, oils, paints, candy, etc., require some definite standard and specification of color. In this connection much fundamental research on photo-electric cells as well as methods of amplification of feeble currents has been necessary, and a spectrophotometer is being built which will supplant the ordinary laborious methods, and substitute for them a rapid and precise automatic measurement.

C. L. Norton

Research has been carried on of a theoretical nature relating to the performance of optical systems in the matter of the amount of light transmitted through them. Papers bearing upon this matter have recently been printed with a special reference to a design of oscillographs and similar recording instruments. Professor Hardy's connection with the committees of the International Congress of Photography has led to the laboratory's engagement to work upon the inter-laboratory standardization of sensitometric practice. Some work has been done upon the technique of color photography with special reference to the making of color photo-micrographs. A method has recently been devised for controlling the intensity of a small lamp without the use of electric measuring instruments. This provides a solution to the problem of the small photometer and exposure meter.

Systematic instruction is now being carried on in the X-ray laboratory to students of most of the engineering departments, both in radiology and in the determination of the X-ray spectra of engineering materials. Investigations are going on as to the internal structure of objects of wood, insulating materials, metal castings, forgings, welded joints, golf balls, etc. A special high precision ionization spectrometer has been built. An extensive investigation has been carried on to determine the precision with which imperfections in density in metals can be determined. Extensive study is being carried on on the structure of refractory materials, especially silicates. Considerable new equipment has been added to the laboratory during the year. The work of this laboratory will be found described in detail in the articles by Professor J. T. Norton appearing in the current numbers of *The Tech Engineering News*.

A spectographic laboratory has been started during the year for the special study of the ultra-violet absorption spectra of organic compounds. It is equipped for this purpose with two of the latest Hilger quartz spectographs including one large Littrow model, giving an exceedingly long spectrum. The necessary electrical equipment for the production of continuous ultra-violet light and spark spectra has been provided. Dr. Henry DeLaszlo, who is in charge of this work, has instituted a course in Spectroscopy for graduate students. The principal research in this laboratory at present is undertaken to determine the connec-

(Continued on page 238)

The Engineering Field

Abstracts from the leading professional and trade journals

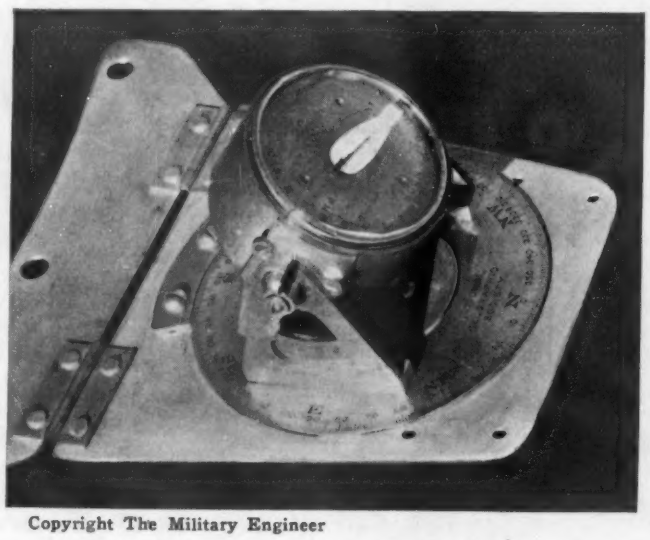
THE BUMSTEAD SUN COMPASS

There are several reasons why a magnetic compass is of no use to an Arctic flyer. The magnetic compass needle is acted on by two forces, that of gravity and that of the earth's magnetic field. The magnetic lines of force leave the earth at one point, travel through a curved circuit through space, and enter the earth at another place. At two points on the earth's surface these lines coincide and make right angles with the surface of the earth. These two places are the magnetic poles and are quite far removed from the geographical poles.

Since a magnetic compass needle is so pivoted that it can move only in a horizontal plane, the horizontal component of the earth's lines of force is the only one that has a useful effect on the needle. Consequently it can readily be seen that at the poles this component is zero or nearly so because of the angle the lines of force make with the earth's surface. In fact a plane over the pole has been turned completely around and the magnetic compass indicated that it was still traveling in the same direction. Also if the plane of the needle is tilted, the force acting on it becomes comparatively great and causes it to appear that a large change in direction has taken place. Since it is impossible to keep an airplane compass level this is a serious difficulty. Another fault of the magnetic compass is that it is subject to declination which varies greatly with the location since the earth is not uniformly magnetized.

The Bumstead Sun compass is so designed that it eliminates all of these errors and was especially designed for the Byrd Polar Expedition. It consists of a clock with a single hand that makes one revolution in twenty-four hours. The clock is mounted above a compass dial and so arranged that it can be inclined at any angle depending on the latitude of the place where it is used. When the clock is tilted at the proper angle the hand follows the motion of the sun just as if it were held level at the North Pole. A shadow pin is mounted on the hand so that the pointing may be done more correctly and when this is done the twelve o'clock mark points towards the South.

The compass dial is so constructed that it is free to revolve on the base on which there is a lubber line that reads against the compass dial the direction which it is desired to travel. When using this compass, it is necessary only to set the clock to the apparent local time, incline it to correspond with the latitude, set the course to be traveled on the compass dial by means of the lubber line, and the proper course is maintained by steering the plane so that the shadow is constantly centered on the clock hand. The only correction necessary is the one for drift which may be determined by using a drift indicator.



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THE BUMSTEAD SUN COMPASS

One of these was used by Byrd in his recent polar flight. The clock dial is 2 1/4 inches in diameter.

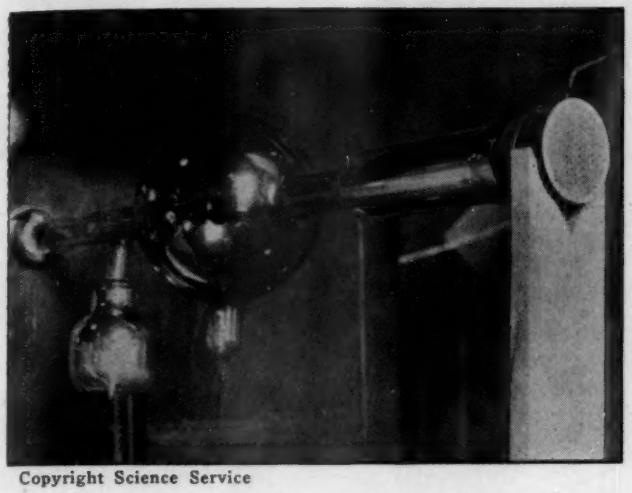
THE FASTEST LIVING THING

has recently been discovered by Dr. Charles H. Townsend, a noted entomologist, in Brazil. It is called the Cephenomyia or in everyday language, the deer bot-fly, and is found in North and South America and in parts of Europe. It travels at a sustained speed of 815 miles per hour, nearly fourteen miles a minute, or four hundred feet per second. This is only one half the speed of a rifle bullet, and three times the speed of the fastest airplane. Its wings, which constitute about sixty per cent of its entire weight, vibrate in all probability, several thousand times a second, while the best airplane propellers rotate at the rate of about 2,000 r.p.m. One of the strangest things about the deer bot-fly is its breeding place, in the nostrils of deer, elk and antelope, and it is from this source that scientists have secured most of their specimens for investigation.

A STANDARD OF PLANENESS.

One of the most accurate pieces of work that has ever been done is the recent manufacture of three disks by the Bureau of Standards, whose surfaces are so flat that at no point do they vary more than 1/100th of a light wavelength from true planes. "Their degree of precision may be illustrated by conceiving them magnified until the disk extends from Washington to Chicago. Then, with the exception of a narrow margin at the edge, no point of the magnified surface would be out of a plane by as much as one inch." Standard plant surfaces have been made before out of glass, but the change in volume due to handling was so great that it was impossible to obtain an accuracy approaching that now obtained.

The use of disks of fused quartz eliminated this difficulty. The Bureau of Standards obtained three quartz disks from 10 to 11 in. diameter, and 1 1/2 to 2 in. thick, and had them roughed into shape. There the disks were ground on each other until they were as flat as a straightedge would reveal. Then they were polished on a layer of pitch, checkered with V-shaped furrows, using a suspension of rouge in water. First a high degree of polish was obtained without reference to flatness. Second they were ground until they were plane as far as tests with a glass standard would indicate. Finally they were ground until, when tested against each other, no variation in height could be determined by any means of measurement.



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THE NEW CATHODE-RAY TUBE

The black object inside the bulb contains the filament and at the right is the nickel window which is three inches in diameter

POWERFUL NEW CATHODE RAY TUBE. Dr. W. D. Coolidge, a graduate of M. I. T., has again made a great advance in science by perfecting the cathode ray tube which has recently been announced to the public. Some of the results that have been obtained with this new tube are well-nigh magical.

One of the most startling of these results is the effect of the cathode rays on acetylene. When a sealed glass tube containing acetylene under pressure was exposed to the rays for a short time, a brown powder was deposited on the walls of the tube. No solvent has as yet been found for the powder, and its chemical composition is unknown.

When a piece of granite is placed before the window of the tube, it has an iridescent glow. Calcite when placed in the stream of cathode rays glows as though it were red hot, although it is cool enough to handle, and moreover, it continues to glow for several hours after the rays have been shut off. Accompanying this glow is a succession of bluish white scintillations at various points on the surface of the crystal.

It has the same effect on flesh as a large amount of radium. When a rabbit's ear was exposed to a beam of the rays for a second, all the hair was singed off a small spot, and a scab was formed. When this scab had healed, a luxuriant growth of white hair appeared in its place. Exposure of one minute caused a scab to be formed on each side of the rabbit's ear. These fell out and left a clean-cut hole. No bad effects on the rabbit were observed.

It is this property which will probably make it very useful as a substitute for radium in medicine for such purposes as curing cancer. Exposure to the rays for a long period would cause death, but there need be no fear of the instrument being used in warfare, as the range of the rays is not more than a few feet.

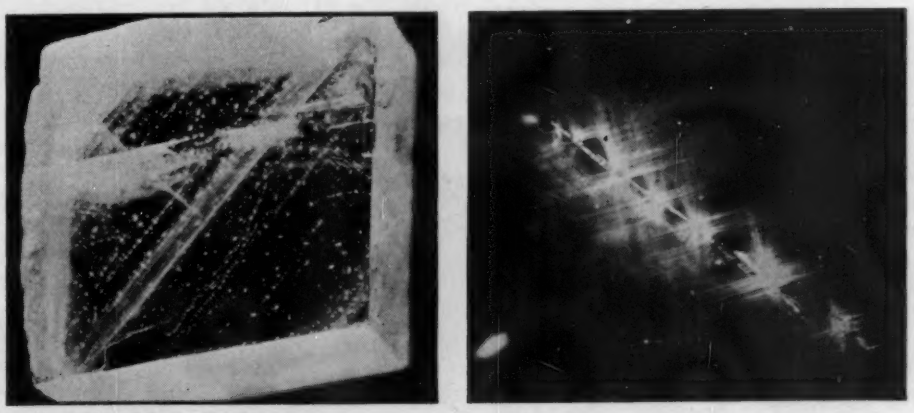
In this tube, the cathode rays are generated by a heated filament just as in a modern X-ray tube. A negative voltage with respect to the anode of 350,000 volts is applied to the cathode. This voltage causes the electrons composing the cathode ray to travel at a very high velocity. These electrons cannot pass through glass, so they do not get outside of an ordinary X-ray tube, but in this tube Dr. Coolidge has provided a window of nickel through which the rays can pass comparatively readily. This window is three inches in diameter, 0.0005 in. thick, and is reinforced by a grid of molybdenum to withstand atmospheric pressure.

SULPHUR IN A NEW ROLE. Sulphur is coming into increased prominence as a protection against corrosion by acids, due to its inert character. Concrete tanks or pipe can be impregnated by immersion in baths of molten sulphur, and wood can be impregnated by forcing the sulphur into it under pressure. Electrolytic cells made of concrete impregnated with sulphur have been used to hold hot solution of ferric and ferrous chlorides, without damage to the steel reinforcing of the concrete. In many cases reinforcing of the concrete is not necessary, as the sulphur itself gives added strength to the concrete.

COLORING CONCRETE WITH DYES. In England is being developed a new process for coloring concrete with organic dyestuffs, instead of using the usual mineral earth colors or pigments. The difficulty of dyeing cement lies in the fact that the cement itself is a very fine powder and the coloring matter must be ground more finely still. If the particles of cement are smaller than the coloring matter, the cement will cover the surface of the pigment so that the resulting color is greyish. In order for the color to show in its true brilliance the pigment must be small enough to color the surface of the cement particles.

This problem was solved in a simple manner. Instead of mixing the cement with water and the pigment in the powdered form, they mix it with some simple compound of the coloring matter. On exposure to air, or by other simple treatment, the coloring matter is precipitated in a very insoluble form upon the cement particles.

The employment in this manner, of organic dyes results in colors which have great fastness, extend over a wide range of shades, and are impervious to atmospheric effects. This has also opened a new and large field for the use of dyestuffs. It is conceivable that in time the production of dyes may be increased 100% by this process, when the amount of concrete used is considered.



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EFFECT OF THE CATHODE RAY

Left—A crystal of calcide glowing with cold light several hours after having been exposed to the rays from the new tube. Right—A magnified view of the surface of the crystal showing the bluish white scintillations

Editorials

AN EXPERIMENT

This month sees a new section added to the service pages of *The Tech Engineering News*. Departmental Notes has ceased to be a talked of editorial policy and has become an established fact. However, the degree to which it has been established is yet to be seen. It is in the nature of an experiment.

We believe that there is a great need at Technology for a medium which can bring to the mind of the undergraduates and the alumni a more or less comprehensive picture of what is actually being done in the higher branches of the various departments. We know that we are connected with a great engineering school. We know that this school does each year a tremendous amount of research work, but here our knowledge stops.

The lower classman is continually trying to piece the work he is doing up with something of a practical nature either to industry or the so-called pure sciences. He wants to know what is going on ahead of him—and he has a right to know. How many underclassmen or upperclassmen, for that matter, know what their own department is doing? And if they know so little of their own department, how can they hope to know what the Institute as a whole is doing? We cannot hope, nor do we wish to report in detail any particular research in this page. We realize that much of the work is paid for by private business organizations and that as such, it is their property and of a confidential nature. What we hope to be able to present is a general picture of the type of work that is being done, the problems solved and the questions still ahead, and news of a departmental nature that should be included, such as changes in the curriculum or methods of instruction, new apparatus that may have been received, and news of a similar nature.

We are often told that we are attending, or have attended one of the finest engineering schools in the world, and that we should be proud of it. There isn't one of us that isn't proud of it—but how many can give the reasons for the pride? To the faculty and to a lesser degree to the alumni, this is a question that can be answered without difficulty, but to the student the answer to the question "Why should we be proud of the Institute?" is a bit intangible.

We hope through our new page to help to show one of the answers to this question. How well we succeed will depend, in a large measure, upon the cooperation of the various departments and on the interest of the student body.

CONSOLIDATING GOVERNMENT PURCHASES

"Efficient procurement requires uniform application of approved methods of purchase and procurement activities." This statement, taken from the report of the Federal Purchasing Board has had its absolute truth attested by the unfailing inclusion, in American business organization, of a Purchasing Department. It has proved essential to efficient operation of all business of any size, to coordinate and engineer the necessary purchasing activities in such a manner as to take advantage of special discounts for large orders and to anticipate and turn to advantage fluctuations of the market.

The scope of governmental consumption is so large and its centers of consumption are so spread over the nation that it might seem, at first glance, a difficult task to place its purchases in the hands of any one organization. Yet the Bureau of the Budget should be congratulated for being now in a fair way toward accomplishing this step which so obviously will effect real economies in expenditures for supplies.

At present many of the departments have each their own purchasing agent, who may or may not have a staff under him. The method now proposed is an expansion of the experimental efforts at wholesale purchasing made last year in gasolene, coal, tires and tubes and surgical supplies. The plan includes the creation of a Federal Purchasing Board, composed of one representative, usually the Purchasing Agent, from each department and the creation of a revolving fund which will permit concentration of its vast buying powers in consolidated purchasing and entering of the markets at seasonal times. With the revolving fund available to be reimbursed by the departments sharing in the purchases, the board believes important savings can be accomplished. The members of the board also serve, in several instances, in other coordinating boards.

If now the plan is sanctioned and placed in operation, will it be practical? The one serious difficulty likely to be encountered, which may render the plan ineffective is interference of politics. The contracts to be let will be fewer in number but larger in value, and may be considered legitimate prey by the politician in search of votes or of personal graft. Let us hope that the new Purchasing Board will find it possible to escape the traps that are sure to be set for it and be rewarded by seeing this method work out as it does in private enterprise, effecting substantial savings.

THE COVER

The original of the pencil sketch reproduced on the cover of this month's TECH ENGINEERING NEWS is by Muirhead Bone, and is the second of his collection of war sketches to be used for this purpose. The gigantic hammerheaded crane from which last month's cover was drawn is again featured but this time from a distance, the perspective lending charm to the detailed harshness of the modern shipyard.

THE COLLEGE MAN

A few months ago there appeared in the Atlantic Monthly an exceedingly interesting and competent article on the subject "Are College Men Wanted." While it deals more with the liberal arts collegian and the business world rather than the scientific and professional there are many phases of the discussion that might profitably be taken to heart by our own undergraduates that would help them to a better understanding of the situations they will soon find themselves in.

Present day literature might seem to the casual observer to be filled with this type of article. Magazines and publishers are all looking for bigger men to write for them on the general topic of the college man. The idea is not new and many of the students dismiss such an article with a superior wave of the hand and the short word "trite." Nevertheless the mere fact that the subject is being discussed is a healthy sign. The difficulty in itself is not new, it is the recognition of the difficulty that is the advance. The first step in the solution of a problem is the appreciation of that problem and a discussion of the factors involved. Let the college man not neglect his opportunity and his responsibility to bring about a better understanding between himself and the non-college world.

Take a tip from the triple-threat man

HE keeps them guessing, does the back, because when he gets the ball he can pass, kick or run—a triple threat.

Men preparing for industry or commerce can put themselves in an equally strategic position. It all gets back to the simple idea of being broad and versatile.

An engineer should be well up on his specialty, of course, but he should also keep an open mind for questions of finance, law and public relations—if he aspires to a high place in the councils of his organization.

Such "all-aroundness" typifies in particular men who have brought the electrical communication industry to what it is today, and who will carry it to still greater development in the years to come.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 62 of a Series

Here and There

Interesting notes from the Editor's desk

MORE WOMEN NEEDED

Several years ago while the Keokuk dam was being constructed by Stone and Webster there were a good many Tech graduates on the job in various capacities. Soon after their arrival these knights of the transit succeeded in finding themselves sweethearts in the vicinity. The result was that when the dam was completed and the men left a shortage of marriageable women was discovered. The man who told us the story reports that if the local swains had not banded together and imported women from the surrounding towns Keokuk would have been faced with a return of innocuous desuetude—so complete had been the triumph of Technology. Of course, the only conclusion to be drawn is that the Institute turns out just as pro- and ee- ficient lovers as it does engineers, and that an electromagnet is not the only attractive thing on earth.

WORSE THAN MEDIEVAL TORTURE

"Poison gas is the worst instrument of warfare ever devised" expound the misinformed. "Any country who would allow its use against their enemies is as uncivilized as the Spaniards were in the time of the Inquisition". Observations in regard to the matter show us that this statement is false and that poison gas is the most humane of all instruments of warfare, if any could be called humane.

During the past War, we find in *The Military Engineer* that only two per cent of the men put out of the War by poison gas actually died, whereas twenty-four per cent of casualties caused by other weapons resulted in death. In other words, poison gas killed only a twelfth as many as guns and bayonets did, taking the percentage of an equal number of casualties in each, (score up one for poison gas).

Then there were 754 men blinded in one or both eyes from war weapons during the War. Of this number, gas was responsible for but 29 cases, or 3.8 per cent, while other weapons were responsible for 96.2 per cent.

Astounding as it may appear, war weapons, other than gas were responsible for all the permanently crippled. There was not a case where gas permanently crippled any soldier.

There were one and a half times as many cases of tuberculosis per thousand occurring among soldiers who were not gassed in France than there were among those gassed. Apparently, this would indicate that poison gas acted as a preventive against tuberculosis.

The above summary of the facts indicate that if the humanity of any war weapon is to be gauged by the amount of suffering it causes at the time of injury, and the degree of permanent disability, and the remote effects resulting from wounds caused by this weapon, poison gas is the most humane of them all. Get gassed, young man, get gassed!

TOY BALLOONS

Speaking of real "go-getters"—here is what the toy balloon salesmen have done to drum up business. They have got the Bureau of Plant Industry of the Department of Agriculture filling their toy balloons with hydrogen, tagging them, and releasing them in wheat growing states where much trouble is being caused by the spread of black stem rust of the wheat.

The tags explain the purpose of the balloon and contain a request for each finder to fill out the blanks and return the tag. Secondary to the great increase in the toy balloon industry which will undoubtedly arise from this new found use, it is hoped that enough of the balloons will be found and tags returned to yield data to estimate the direction and distance the rust spores may have been carried by the wind.

CRUEL TRICK

From *Time* comes an account of "one of the cruelest tricks one civilized being could well play upon another. It was a letter left by the late Professor Paul Kammerer, famed biologist, who ascended a small hill near Vienna last month and shot himself. For a year the scientific world had reverberated with Professor Kammerer's report that, by experiment upon frogs, he had proved to his immensely critical satisfaction that acquired characteristics, such as the loss of an arm, blotches on the skin, could be passed from one generation to another. It was contrary to all previous observations on the transference of physical characteristics and Professor Kammerer was hailed by some as brilliant genius, by others as deluded fool. Dr. G. K. Noble of the American Museum of Natural History examined Professor Kammerer's depositions and in an article for *Nature* (British Monthly) drew the lenient conclusion that someone may have tampered with Dr. Kammerer's specimens. In particular, certain dark spots on some of the frogs might have been produced, not by inheritance, but by injecting a dark fluid under the skin, perhaps India ink. When he saw this suggestion, Dr. Kammerer, who had lately been offered charge of a new government laboratory in Russia and whose suicide was to be a shock and a mystery to the many scientists that had long held him in high esteem, investigated at once.

"'All the facts are true,' said Dr. Kammerer's last letter, referring to Dr. Noble's article. Assistants, perhaps malicious, perhaps longing to see their master pleased, had tampered with the frogs. 'The work of my whole life has been destroyed'."

CHEESY MUSIC

It is part of the process in finishing phonograph records to make a copper plate of the sound impressions by an electrolytic method. According to Dr. William Blum, Chemist of the U. S. Bureau of Standards, there was much glee in one of the electroplating companies when an increase in hardness was noticed in these disks. Naturally an effort was made to find out the reason. An analysis of the plating bath revealed the presence of organic matter.

At a complete loss to explain the presence of any foreign matter in their electrolytes used for depositing copper electrically, a careful inquiry developed the fact that an Italian laborer had playfully flipped a piece of cheese at a fellow worker, the cheese missing its mark and falling into the tank where the metallic disks containing phonographic records were being deposited. The phonograph company found that the hardening effect was due to the casein in the cheese, which material they therefore have continued to add to their solutions. The increased hardness of the copper allows a considerable saving because more records can be stamped in molten wax from the harder disks.

MAKERS OF POWDERS SINCE 1802

Progression

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Professional Notes

Activities of the Undergraduate Engineering Societies of the Massachusetts Institute of Technology

AERONAUTICAL ENGINEERING SOCIETY

With a membership more promising than ever before, the Aeronautical Engineering Society started its year with an afternoon talk by Major Lester D. Gardner on Monday, October 25th, at 4:00 P.M. Although that hour of the day was a busy one, there was a large number present, and all were very much interested in Mr. Gardner's entrancing description of his European Tour by air.

Last summer he flew over 21,000 miles by air over the continents of Europe, Asia, and Africa. This was largely done in regular commercial planes flying on schedule, and extending to such far off cities as Casablanca, Constantinople, Moscow, and Stockholm. Mrs. Gardner accompanied him on most of the flights and is an enthusiastic booster of air travel. A part of his flight was made possible through the courtesy of the Royal Air Force which transported him from Alexandria and Cairo, across the Arabian Desert to Babylon, Nineveh, and the Iraq region, and then flew him back over the Holy Land. During all this traveling, some of which was done by night, not a single forced landing was encountered, and he was only delayed in his schedule once, and then only long enough to procure more gasoline.

Mr. Gardner illustrated his talk with slides depicting the work and the actual flight of the Imperial Airways between London and Paris. There was a long informal discussion held after the meeting, during which Mr. Gardner answered many of the questions that have been raised by Americans concerning the real status of European Aviation.

On Thursday, October 28th, a number of the members of the Aero Society attended the luncheon at the Chamber of Commerce to hear Mr. Anthony H. G. Fokker speak, and two tables were reserved for them near the front.

A very extensive program of smokers is planned for the winter, and several trips to nearby establishments of aeronautical interest are being arranged. Dr. Von Carmen, to speak on gliders, and Captain Stevens of the Army to describe the Rice Expedition by plane up the Amazon, are among the first.

FRANKLIN T. KENT

CIVIL ENGINEERING SOCIETY

On October 20, the M. I. T. Student Chapter of the American Society of Civil Engineers participated in a joint meeting sponsored by the Boston Society of Civil Engineers. The lecture was attended by more than one hundred members of the M. I. T. Chapter.

The Society's program for the year will consist of lectures on each of the following subjects pertaining to the profession:

Highway Engineering
Hydro-Electric Engineering
City Designing and Planning
Building Construction and
Sanitary Engineering

The officers intend to procure movies for at least one of the smokers. It is hoped that activities along Civil Engineering lines around Boston will afford us an opportunity to make one or two trips. Plans call for a banquet about the middle of May.

The members of the M. I. T. Chapter have been invited by the Affiliated Technical Societies of Boston to use their library and reading rooms located in Room 715, Tremont Temple, Boston. Civil Society members are also extended the privilege of attending all of the Societies' meetings.

Every month the Society receives copies of Part II Proceedings of the American Society of Civil Engineers, which will be distributed to its members. For the interest of the Seniors it is timely to know that Employment Bulletins .given thru the courtesy of the A. S. C. E. will be placed in their hands, beginning early in April.

The membership campaign resulted very favorably and the goal of (250) members will be reached before Nov. 1st. It is hoped that eligible men, not members, will try and join, as it depends upon their cooperation whether the Technology Chapter is first of the Student Chapters in the Nation.

CORPORATION XV

The activities of Corporation XV for the ensuing year promise much in the line of educational value and the development of a good fellowship among its members. Officers and directors have been elected as follows: President, Charles C. Smith, '27; Secretary, Alden G. Reed, '27; Treasurer, Alf K. Burle, '27; Senior Directors: Thomas F. Russell, '27, Richard P. Dixon, '27, Colin A. MacDonald, '27; Junior Directors: Charles E. Richheimer, '28, Howard W. Miller, '28, Marcus W. Keyes, '28.

The first of a series of Dinner Meetings was held in the Walker Grill Room on Friday, October 29, 1926, and proved to be an excellent impetus for the program of events for the year. Dr. Davis R. Dewey, head of Course XV, gave an interesting and humorous retrospection of the activities of Corporation XV since its incorporation in 1921. Needless to say his talk was received with the same spirit of fondness which always greets Dr. Dewey whenever he is among the students. From the outside field, Mr. Edwin C. Johnson, President of the H. A. Johnson Company, gave an address on the essential characteristics of a successful business man as they appear to him after an extensive experience in business. He spoke of Honesty, the development of imagination, the ability to think, self analysis, and the utilization of prayer and religious affiliations as a means of maintaining harmonious relationships in the business world.

ALDEN G. REED, '27
Secretary.

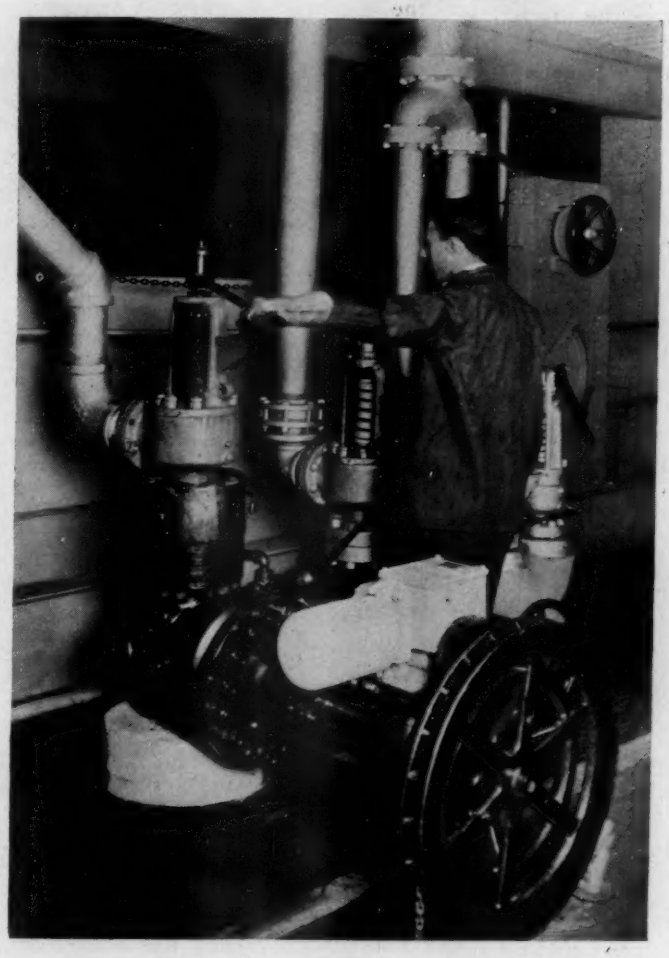
ELECTRICAL ENGINEERING SOCIETY

Meetings twice a month are being held by the M. I. T. Branch of the American Institute of Electrical Engineers this year. In addition to the regular monthly meetings or trips as in previous years, members of the M. I. T. Branch have been invited to participate in the meetings of the Boston Section A. I. E. E. In this manner, the student group will be able to hear speakers whom they otherwise could not secure.

An inspection trip to the new automatic station of the Edison Electric Illuminating Company of Boston on Cambridge Street opened the 1926-27 season on October 18. The meeting began in Gilbert Hall, Tremont Temple, where a buffet supper was served. Descriptions of features of the station were given by Edison engineers after which adjournment was made to the station. By simulating line conditions of increasing and de-

(Continued on page 242)

STANDARDIZED SAFETY VALVES For High Pressures



THIS VIEW SHOWS

testing unit of the High Pressure Steam Testing Laboratory of the Consolidated Safety Valve Company, Bridgeport. An actual test is being made of one of the drum valves for the 1200-lb. boiler installed at the Weymouth Station of the Edison Electric Illuminating Co. of Boston.

POWER PLANT engineers are turning to higher steam pressure as a means of economy in producing cheaper power. From 300 lbs., the highest pressure generally used a few years ago, has come the remarkable advance to 400, then to 600, 700, and finally to 1200 lbs. per square inch.

Consolidated Safety Valves tested upon the new 1200-lb. Steam Testing Laboratory of The Consolidated Safety Valve Co. have been installed, or are being furnished, for practically all of the higher pressure stations such as the following:

Form DSA Valves for stations carrying approximately 400-lb. pressure as follows:

The Trenton Channel Station of The Detroit Edison Co.

The Richmond Station of the Philadelphia Electric Co.

The Avon Station of the Cleveland Electric Illuminating Co.

The 14th Street Station of the New York Edison Co.

The Spencer, North Carolina, Station of the Southern Power Co.

Form DSB Valves for stations carrying approximately 600-lb. pressure as follows:

The Philo Station of the Ohio Power Co.

The Crawford Avenue Station of the Commonwealth Edison Co.

The Twin Branch Station of the Michigan & Indiana Electric Co.

The Miami Fort Station of the Columbia Power Co.

Form DSC Valves for the Stanton Power Station of the American Gas & Electric Co., carrying approximately 700 lbs.

Form DSC Valves for the Weymouth Station of the Boston Edison Company, carrying approximately 1200 lbs.

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BRIDGEPORT WORKS—CONSOLIDATED SAFETY VALVE CO.

Conowingo

(Continued from page 219)

them will close most of the entrance to the two parts of a waterway. The top of each opening will be closed by special sealing sections which can be removed easily when it is desired to fill a scroll case with water, thus balancing the pressure on both sides of the main panels before they are removed.

The waterway openings through the headworks section for the four future units will be closed by steel stop log sections similar in design to the sectional head gates. These stop logs are, however, made in smaller sections as this will be the last section through which the river will be passed and the stop logs must be placed while water is passing through the openings.

As each water wheel will require about 5300 sec. ft. of water for full generator load at 89 ft. head, a wide bell mouth entrance will be provided for the waterways to insure satisfactory hydraulic conditions for the intake with the head loss at the entrance reduced to a minimum. The area of this entrance is about 1900 sq. ft. and to close this area with two or three gates of any developed type would require gates of a very large size under the pressure they would have to resist. Consequently, difficulty would be experienced in obtaining an adequate seal against leakage and the operating mechanism required would be expensive and the operation slow.

After a thorough study of the different types of gates it was decided that the most practicable to suit the conditions would be vertical shaft, circular type, butterfly valves, located at the entrance to the scroll case. At this point the area to close is only about 570 sq. ft. and the perimeter to be made tight is only about 85 ft. for the circular gate as compared to an area of 1900 sq. ft. and a perimeter of 350 ft. for rectangular gates at the entrance to the waterway.

These butterfly valves will be 27 ft. in diameter and the wickets and housings will be made of cast steel. The vertical load from the wicket of each valve will be carried on a thrust bearing located below the valve and the upper half of the valve housing will be designed so that it may be removed by a power station crane and the wicket removed in case of an emergency. The valves are designed to open or close in about five minutes, and may be closed with the maximum flow through the turbine. In the closed position the wicket will stand at right angles to the line of flow and the valve will be sealed after closing by admitting water pressure to a 3 in. diameter rubber tube set in the inside face of the valve housing opposite the periphery of the valve wicket. Based on shop tests of this sealing device the leakage through these large valves will be negligible. The valves will be operated by oil pressure in 40 in. diameter operating cylinders and supplied from a central pressure oil system.

These valves will be the largest ever built, the largest previous installation being the 23'-6" diameter valves used at Niagara Falls. The sealing device will be the same for all valves as will the design of the bearings, operating mechanism and renewable parts, the two manufacturers having co-operated to make such parts of both the water wheels and butterfly valves alike and interchangeable.

The two station service units will also be provided with motor operated butterfly valves which will be 6 ft. in diameter.

Each main unit will consist of a 40,000 k.v.a. 13,800 volt, 3 phase, 60 cycle, vertical generator, directly connected to a water wheel designed to have a capacity of 54,000 h.p. at full gate and 50,000 h.p. at the point of best efficiency when operating at 81.8 r.p.m. under the average net head of 89 ft.

Each station service unit will consist of a 1600 k.v.a. 460 volt, 3 phase, 60 cycle, vertical shaft generator, direct connected to a 1900 h.p. 360 r.p.m. 89 ft. head water wheel unit. These water wheel units will be of the single runner Francis reaction type, equipped with plate steel scroll cases and oil relay governors of the torsion shaft type.

Each main generator will be 37 ft. in diameter and will be provided with a direct connected 715 k.v.a. auxiliary a.c. generator and a small direct connected exciter for the auxiliary generator. A separate motor generator set driven by power from the auxiliary generator will supply the excitation current for the main generator.

Each generator will have a steady bearing above and one below the rotor and the weight of the rotating elements, together with the hydraulic thrust of the water wheel will be carried by a thrust bearing on top of the generator. These bearings will all be oil lubricated, the oil being circulated to the bearings by an oil pump driven directly by gears from the shaft. The thrust bearings on the units furnished by the General Electric Company will be of the spring type, while the thrust bearings on the Westinghouse generators will be of the Kingsbury type.

The guaranteed efficiency of the main generators will be in excess of 97% at rated capacity.

The water wheel units will be of the single runner Francis reaction type, with actuator type governors and plate steel scroll cases and will be the largest units in physical dimensions built to date.

It is expected that these water wheel units will have a maximum efficiency of at least 93%. Each runner will have a maximum diameter of 17'-9", will be of cast steel, cast in not more than four parts and when completely assembled will weigh about 240,000 lbs.

The steady bearing for each water wheel unit will be of the water lubricated lignum vitæ type. This bearing will be adjustable so that it may be easily lined up and tightened after it has become worn.

Plate steel scroll cases will be used because of their greater economy when compared to concrete which would require heavy reinforcing in the substructure and very expensive form work. The plate steel scroll cases will also reduce greatly the danger of leakage and permit the use of much thinner concrete sections.

The shaft for each main unit will be of forged steel about 36 in. in diameter with top and bottom flanges forged integrally with it.

Each main unit will have a structural steel pit liner and generator support attached to the top of the speed ring and designed to carry the entire weight of the generator, the thrust bearing load and the adjacent floor loads to the speed ring. The steel support was decided upon as it would be difficult to design a concrete foundation for the generator in the space available to transfer the enormous load to the speed ring, through which it must be carried to the substructure foundation.

The governors for the main units will be of the oil pressure relay actuator type with governor flyballs mechanically driven from the main shaft of the water wheel. For each pair of units, there will be an inter-

(Continued on page 244)

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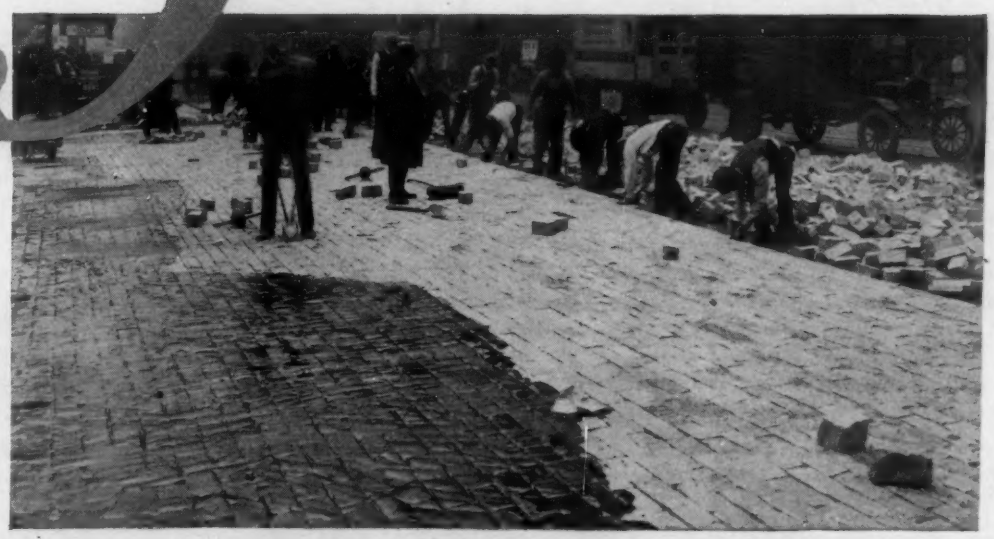

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Departmental

(Continued from page 227)

tion between the chemical constitution and absorption of radiant energy with particular reference to cases of isomerism in the benzene and naphthalene series.

To the equipment of the general spectroscopic laboratory has been added a large Geneva universal spectroscope and comparator with complete sets of quartz and glass prisms. A small Steinheil quartz spectrograph and a larger one from Hilger, have made it possible to begin systematic undergraduate instruction and graduate research in this laboratory. A study by Doctors Allis, Muller and Frank upon the Lichtenberg figures, and a series of investigations by Dr. Muller on the coagulation of colloids and of the catapheretic colloids are under way. Dr. Muller is also carrying on work in connection with the activity coefficient of small ions.

C. L. Norton

(Continued next month)

X-Ray Spectroscopy

(Continued from page 217)

ured in the following way: The so-called general or continuous radiation given off by an ordinary X-ray tube is composed of a wide range of wavelengths whose intensity is sensibly the same or at least varies in a continuous fashion. If this general radiation is resolved by a rotating crystal and recorded photographically it will appear as a general blackening spread out on the film. If, however, an absorbing screen of a certain element is placed in the path of this beam, the general radiation of wavelengths shorter than that of its characteristic absorption value will be much more strongly absorbed than those wavelengths which are longer than this value, and the blackening of the film at this point will undergo a very sudden change in intensity. Since every point on the film corresponds to a definite wavelength value, the wavelength of the absorption edge may be determined from its position. Such an absorption edge is plainly shown in Figure 2. Each element has a definite absorption wavelength corresponding to it, and the change as one passes from element to element is very similar to that of the emission wavelengths.

For an analysis of this sort, the sample may have a number of different forms. Thin sheets of various sorts may be used placed over the slit of the spectrograph, but the thickness should not be great enough to reduce the intensity of the beam to a very great extent. Powders of various sorts may be mixed with suitable binders, and spread in thin layers on cards. Filter paper may be saturated with solutions, dried and placed in the path of the beam. Even liquids and gases placed in thin walled containers may be used provided their absorption is sufficient. It is evident that this method is much more versatile and more simple than the preceding one because no special type of X-ray tube is necessary, but it is not as sensitive in the way of indicating the presence of very small quantities of an element. The absorption method has the possibility of being developed in a quan-

(Continued on page 240)

WIRE automobile and airplane wires, electrical wires, submarine cables, bridge-building cables, wire rope, telegraph and telephone wire, radio wire, round wire, flat wire, star-shaped and all different kinds of shapes of wire, sheet wire, piano wire, pipe organ wire, wire hoops, barbed wire, woven wire fences, wire gates, wire fence posts, trolley wire and rail bonds, poultry netting, wire springs, concrete reinforcing wire mesh, nails, staples, tacks, spikes, bale ties, steel wire strips, wire-rope aerial tramways. Illustrated story of how steel and wire is made, also illustrated books describing uses of all the above wires sent free.

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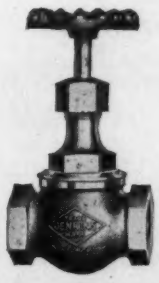

Fig. 106

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X-Ray Spectroscopy

(Continued from page 238)

titative way by measuring the relative amounts of blackening on the two sides of the absorption edge, and comparing with similar films of known proportions. The blackening of the film is determined quantitatively by a densitometer.

The type of problem to which these spectral methods may be applied will be quite evident from the details of the methods themselves, but perhaps mention should be made of what is perhaps the most outstanding success in the case of the emission spectra. In the search for some of the missing elements of the periodic system, chemical analytical methods were often difficult because so little was known of the properties of these new bodies. It was possible, however, from theoretical considerations to predict the wavelengths of the emission lines in the X-ray spectra very accurately. In at least two cases the X-ray spectra disclosed the predicted lines of the element for which search was being made. Other applications would be in the cases of the study of small quantities of alloy materials in special steel, the analysis of very insoluble substances, identification of small quantities of the more rare elements whose methods of chemical analysis have not been developed, and many others which will suggest themselves.

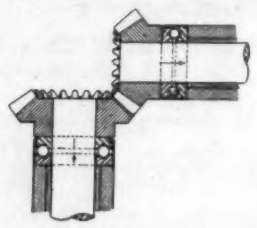
In the two methods just considered a more or less heterogeneous beam of X-rays has been analyzed by a crystal of known constants. In the method of diffraction to be described, the inverse process is employed, a beam of a single known wavelength being used to determine the spacings of the various atomic planes of a crystal. The principle is essentially the same. A particular wavelength will be reflected from the cleavage face of a crystal at an angle which depends upon the distance apart of the atomic planes parallel to this cleavage face. If the spectrograph previously described is used, and the various faces of a crystal are presented in turn at the proper angle for reflection, the reflected beam will make its record on the film at the corresponding angles, and a line will appear for each value of the planar spacing. Thus each line of this so-called diffraction pattern will correspond to some definite distance between atoms in the crystal. Because each family of atomic planes has to make exactly the correct angle with the X-ray beam in order to reflect at all, it is common practice to use the crystalline sample in a fine grained form with the grains in a random or chaotic arrangement so that there will be at least a few representatives of every possible family of planes making the correct angle and all of the reflected beams will appear simultaneously. This is known as the method of the powdered crystal, and an example of such a diffraction pattern is shown in Figure 4.

The relative positions and intensities of the lines of the diffraction patterns is characteristic of the way in which the atoms are arranged rather than of the atoms themselves, and hence the method is useful in studying a definite class of problems dealing with regularly arranged groups of atoms, and these substances are known as crystalline. They form a very great portion of our useful materials, and the subject is one of considerable importance. By comparing diffraction patterns of pure standard substances with the unknown pattern, identification is possible. Not only is the arrangement determined, but because of the actual values of the spacings, the nature of the substance also, and so far, no two substances have been found which have exactly the same diffraction patterns.

There are numerous ways in which the samples may be prepared for examination by the diffraction method. Perhaps the most common method is to grind the sample in a very fine form and mount in a fine, thin walled glass tube. Often the tube is divided and a standard sample placed in one-half so that the known and the unknown may be compared on the same film. Metal samples may be powdered, but are frequently used in their natural fine grained form in

(Continued on page 246)

BEVEL GEARS



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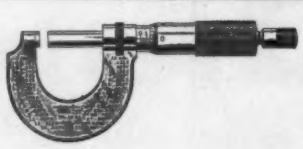

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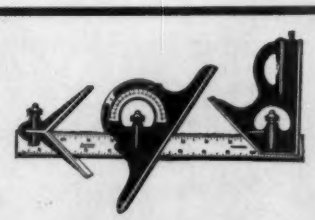

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Professional Notes

(Continued from page 234)

creasing load, the engineers were able to demonstrate the control of the motor-generator set through the automatic apparatus.

Artificial lightning and high voltage A. C. discharges were produced at the laboratory of the Simplex Wire and Cable Company for the Society during its trip to the company's plant on November 2. Insulator flashovers and needle point discharges at over half a million volts were shown.

"New Landmarks in Electrical Communication" will be the topic of a lecture at a meeting of the Section to be held in Tremont Temple, November 16. In this talk Mr. Paul B. Findley of the Bell Telephone Laboratories will discuss the difference in point of view between the power engineer and the telephone engineer. Mr. Findley will give demonstrations by means of a phonograph to illustrate his points. He will also show the new motion picture film "The Magic of Communication".

The Regional Student Branch Convention will be held in Pittsfield, Mass. on May 27, 1927. Papers selected by competition will be delivered there. As these Student papers will be eligible for the National and Regional "Best Branch Paper Prizes" of $100 and $25, it is hoped that many of the 175 members of the M. I. T. Branch will compete.

MINING SOCIETY

The Society's first meeting of the year was held Wednesday, October 27, at 6:30 P.M. in the New University Club. It was the annual joint meeting and dinner of the Boston section A.I.M.M.E. with the affiliated student societies of Harvard, Tufts and Tech. There were fifteen members of the Tech society present.

Prof. Hayward, Chairman of the Boston Section A.I.M.M.E., presided at the meeting which was held directly after the dinner. The presidents of the several student societies gave short addresses after which Prof. Richards and several members of the Boston section spoke a few words.

The principal speakers were Mr. Taylor, president of the A.I.M.M.E., and Mr. Baine, secretary of the A.I.M.M.E. Mr. Taylor has had long and varied experience in the iron and steel industry and is one of the trustees of the University of Pittsburgh. Mr. Baine has had wide experience as a consulting Mining Engineer and was at one time Director of the U. S. Bureau of Mines.

In his talk, Mr. Taylor spoke of the many problems met with in the teaching of students to be engineers. He expressed himself as not favoring any extension in the length of college courses required for engineers, because he believes that since the average engineering student does not know what he will do after graduation, it is better to get only the fundamentals of engineering at college and get the details on the job.

Mr. Baine spoke on the subject of "Holding a Job." He advised that the young engineer should get as wide and varied an experience at first as possible since this would aid him when he later came to take a more permanent place in some organization. He said that the engineer should avoid getting the idea of being just a job holder.

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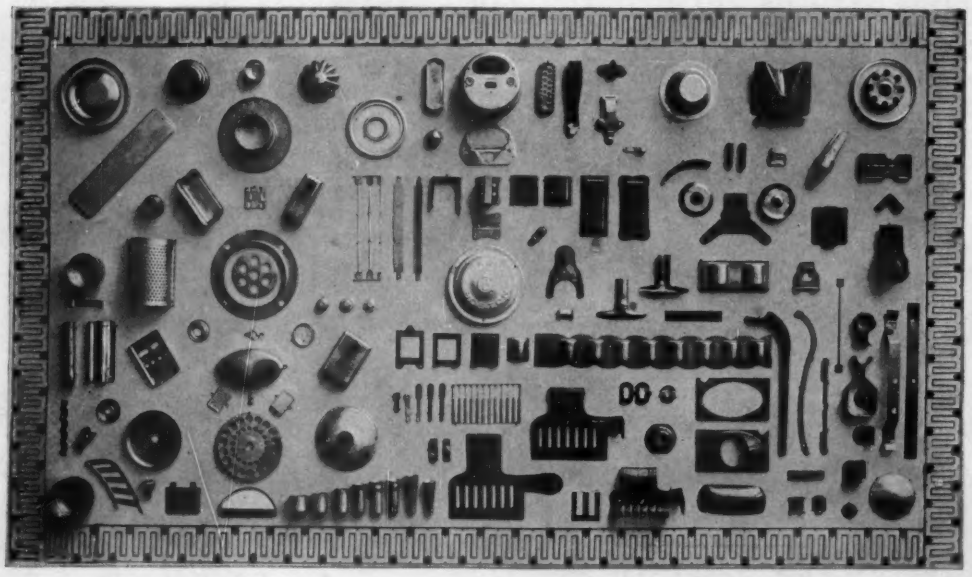

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Conowingo

(Continued from page 236)

connected oil pressure system having duplicate oil pumps, a single pressure tank and two sump tanks.

To renew the oil for the governors and oil bearings of the units, there will be a central oil storage and purification system.

The draft tubes for each make of water wheel will be built in accordance with the design of their respective manufacturer. The Cramp units will have tubes of the Moody spreading type with a concrete cone extending from the bottom at Elev.-14.5 ft. to the hub of the runner. The Allis-Chalmers' units will be equipped with the White Hydraucone type of draft tubes with a bottom level at Elev. —18.5 ft. The bottom of the outlet ends of the draft tubes for all units will be at the same elevation.

The substructure over the draft tube of each unit will be supported by five cast steel stay vanes which each manufacturer is furnishing for the units he supplies. Downstream from this circle of stay vanes the draft tube will be divided into two parts by a central bearing wall of reinforced concrete.

The low setting of the water wheels relative to the tailwater level, required for the protection of the runners against pitting, makes it necessary to provide guides for stop logs at the outlet of the draft tubes to keep out the tailwater when a unit is unwatered for inspection or repairs. A set of structural steel stop logs sufficient to close off the outlet from one main unit draft tube will be supplied. These stop logs will be handled by a small gantry crane operating on a runway along the downstream face of the power station.

The power station building will have a massive reinforced concrete substructure and a steel skeleton reinforced concrete superstructure. The main generator room which will be on the downstream side will be about 71 ft. wide by 66 ft. clear height and 620 ft. long, for the initial development. At the shore end of this room will be a large dismantling space for repair work on the main equipment. Next to this space will be the two station service units, arranged at right angles to the main axis of the room. The main units will be spaced 72 ft. center to center along the axis of the room. The main floor of the room will be at Elev. 46.0 ft. with a gallery along the upstream side of the room and around each generator at Elev. 60.0 ft. The motor generator exciters for the main units will be located on this latter gallery between the main units. The governors and the generator rheostats, as well as the butterfly operating mechanisms, will be located on the main floor at Elev. 46.0 ft. The generator room will be equipped with two electric traveling cranes, each having a main hoist of 150 tons capacity and an auxiliary hoist of 25 tons capacity mounted on the same trolley.

Upstream from the generator room will be the electrical bay, which will be about 31 feet wide. This bay will house the low tension bus and breakers, station service and lighting transformers and feed regulators, the battery rooms and the main and station service control rooms. The main step-up transformers will be located on the roof of the electrical bay between the control rooms. There will be a bank of three 26,667 kva. transformers for each two main units. The 220 kv. circuit breakers, as well as the high tension bus and switching structure, will be located on the roof of the generator room.

Upstream from the generator room, at the shore end of the electrical bay, will be a six-story office bay 32 ft. wide by 90 ft. long. The main entrance to this office building will be at

(Continued on page 246)

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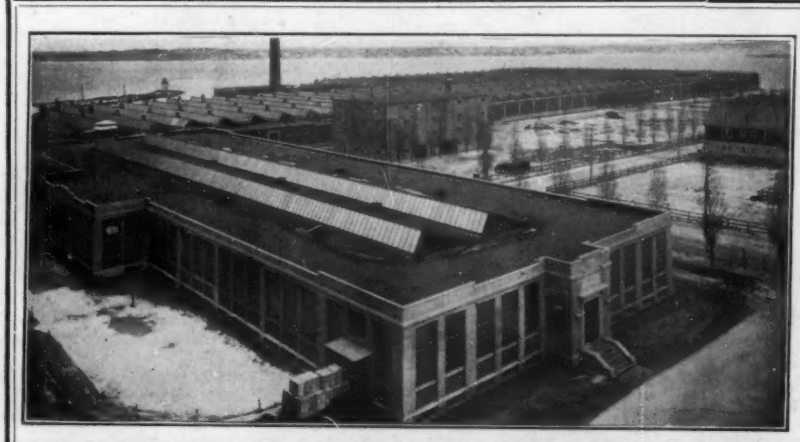

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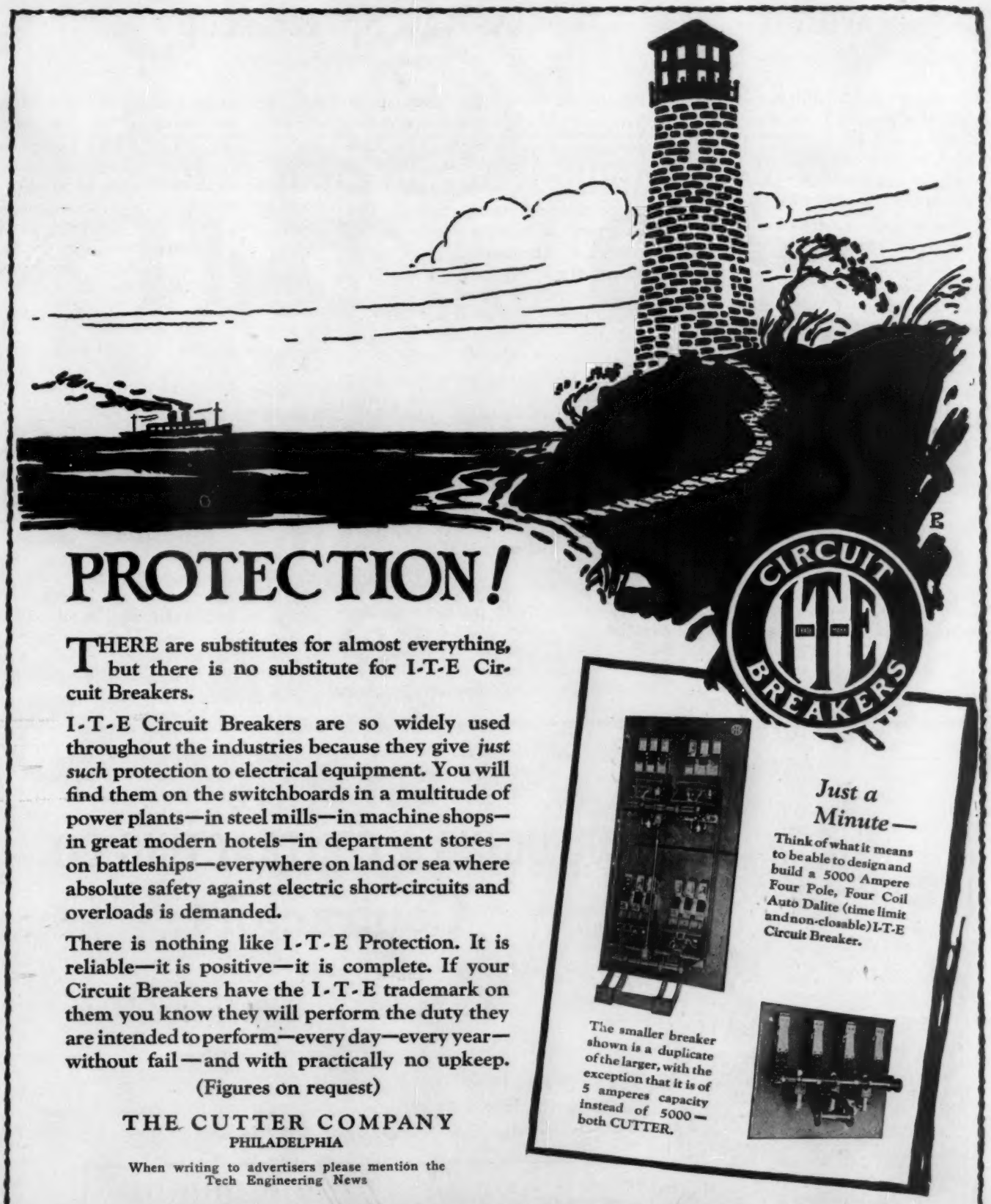

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THERE are substitutes for almost everything, but there is no substitute for I-T-E Circuit Breakers.

I-T-E Circuit Breakers are so widely used throughout the industries because they give *just such* protection to electrical equipment. You will find them on the switchboards in a multitude of power plants—in steel mills—in machine shops—in great modern hotels—in department stores—on battleships—everywhere on land or sea where absolute safety against electric short-circuits and overloads is demanded.

There is nothing like I-T-E Protection. It is reliable—it is positive—it is complete. If your Circuit Breakers have the I-T-E trademark on them you know they will perform the duty they are intended to perform—every day—every year—without fail—and with practically no upkeep.

(Figures on request)

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The smaller breaker shown is a duplicate of the larger, with the exception that it is of 5 amperes capacity instead of 5000—both CUTTER.

CUTTER

U-RE-LITE I-T-E CIRCUIT BREAKERS

10

Conowingo

(Continued from page 244)

the top floor, which will be at the grade of the highway on the dam. The building will be equipped with a combined freight and passenger elevator with a capacity of 2500 lbs. or fifteen people.

All design and construction operations are under the supervision of Dr. W. C. L. Eglin, Vice President and Chief Engineer of The Philadelphia Electric Company. Contract for the design and construction of the dam and power house was awarded to Stone & Webster, Inc., who have associated with themselves in the construction work of the dam The Arundel Corporation of Baltimore. Day & Zimmerman, Inc., have been awarded the contract for the design and construction of the transmission lines and for the switching station, located on the roof of the power house.

Construction work started on the project early in March, 1926, and it is expected that the initial installation will be completed so that power from Conowingo will be available to help carry the peak load of The Philadelphia Electric Company's system in December, 1928.

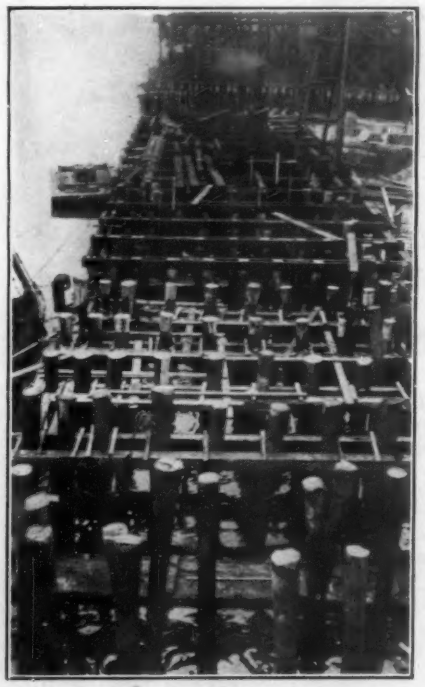
X-Ray Spectroscopy

(Continued from page 240)

the shape of wire, thin sheet or a specially shaped, thin edged specimen. Powder may also be used when compressed into rods or mixed with a non-crystalline binder and made into filaments of one form or another. The apparatus while similar to the simple spectrograph in principle, has taken on many forms depending upon the particular type of work anticipated. One instrument, designed for more or less routine work is capable of making patterns of sixteen samples at once, and as the exposures are quite long (15-30 hours) this means a considerable saving of time as well as increasing the effective life of the tube.

The X-ray diffraction method of identification has many applications in all scientific fields. In the case of metallurgy, for instance, the method is useful in the study of mixtures and solutions in the solid state, the existence of intermetallic compounds and question of allotropic forms. In geology and mineralogy also, allotropy is very important. The diffraction method seems to be very well suited for the investigation of ores and minerals, and many of the less common minerals can be readily identified in this way. In some cases even the well-known substances fail to be recognized by ordinary methods. Figure 4 shows the diffraction pattern of a sample of supposed marcasite on the same film as a standard sample of pyrite. It will be observed that the agreement is perfect. Since the patterns of true marcasite and true pyrite are not at all similar, there is only one conclusion to draw. This is a typical example.

From the preceding description, it is evident that the X-ray methods are capable of furnishing a very fundamental means of identifying substances of various kinds and of making this identification, not only from the atomic point of view, but also by indicating the way in which the atoms are arranged with respect to one another. The methods as yet are in their infancy, as compared with most of the better known ones, but they will be developed as fast as they become necessary, and it seems as if we may expect great things of them in the future.



View showing construction of oak pile wharf, same to be 650′ long, now under construction for the Lynn Gas & Electric Co., at Lynn, Mass.

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One firm reports a 28% reduction in heat cost, for one process, through using gas.

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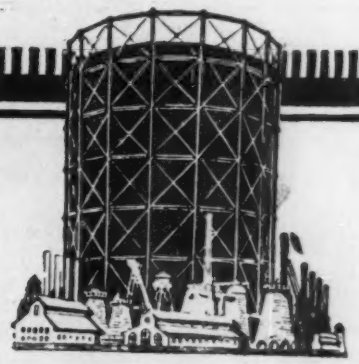
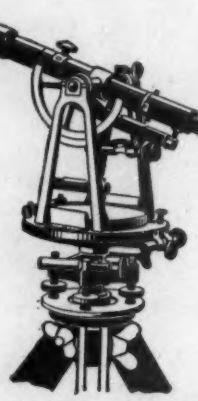


Hydro-Electric

(Continued from page 221)

The layout in Fig. 5 is a further elaboration in that double high tension buses and two oil circuit breakers per circuit are used. This will present greater flexibility under operating conditions than shown in Fig. 4. Also provision is made for low tension parallel operation and reactances are shown located between each generator terminal and the synchronizing bus. This layout would apply to a large system where a high degree of service assurance and operating flexibility are warranted.



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BUFF

TRADE MARK TRADE MARK

The Engineer in Exports

(Continued from page 215)

markets frequently depend upon the character of technical service rendered by the seller, and competition is slowly but surely making this a major issue. The highly specialized "expert," because of his narrowness, and often because of his stubborn adherence to set ideas, does not meet the situation adequately, and is giving way to the more broadly trained "engineer."

Prospects for the engineer in foreign trade are by no means limited to technical lines. All around us in this country we find technically trained men successfully engaged in commercial and financial pursuits remotely or not at all related to their original profession. The thorough grounding in fundamentals and straight-thinking habits which are practically forced upon the engineer in the course of his training have been found applicable to a wide range of other problems. In dealing with the varied and novel questions which are continually cropping up in the pursuit of foreign business, the man who has engineering training in addition to the required qualifications of aggressiveness, tact, and adaptability will find his special qualification a distinct asset, whether or not he is directly concerned with engineering work.

As to the matter of which technical courses provide the best fundamental training for prospective export engineers or salesmen, those including a fairly large proportion of general and commercial subjects will be found of most practical value. While it is possible to carry on business operations in practically all parts of the world by use of the English language alone, there are many large fields where knowledge of other languages will be found a valuable asset. The languages ranking next to English in general usefulness throughout the world are Spanish, French, German, and Italian —in the order named.

Regarding the possibilities for advancement and return to the United States after a term of service abroad, the various exporting firms differ so widely in policy that a general statement on this matter would be entirely inadequate. The usual term of foreign service ranges from two to five years, with a home leave of six months to one year for each term. With those firms having permanent field organizations the chances are that a man once established abroad will be continued in the field staff for several terms. The better organized companies have an age limit at which the foreign representative may retire on part pay—the limit usually being between forty and fifty years of age. As exporters come to realize that home trained men are not fully equipped to handle foreign business there will undoubtedly be more and more opportunities for field men to step up into executive positions in their home offices. There is a visible tendency in this direction at the present time.

Future Prospects

Indications point to a steady growth of American export trade. Asia, containing approximately one half of the world's population, offers a potential market of enormous proportions; Russia shows signs of giving up the old policy of equal destitution for all and taking a new hold on life, with the aid of imported machinery and materials; the possibilities in markets already developed are by no means exhausted. Our production and shipping facilities are already going concerns, and experience proves that the American exporter who knows his business and works at it seriously can hold his own against the strongest of foreign competitors. American export business is certainly going ahead and offers the engineer those opportunities which go with a young and growing industry.

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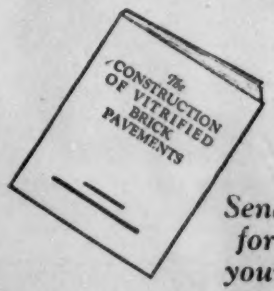

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Broadcasting from CRH

C. R. HANNA

"NEVER heard of station CRH", you'll say. Quite naturally, for CRH is not a station. CRH is Clinton R. Hanna, age 27, out of Purdue less than five years, a Research Engineer with Westinghouse at East Pittsburgh.

Any time you're listening to your radio, however, you may be getting better reception, a clearer program, because of CRH and the improvements in reproducing apparatus to which he contributed.

That story goes back to undergraduate days at Lafayette. Hanna, as a student, developed an intense interest in radio; and, making capital out of his hobby, his thesis was entitled, "Interrupter Type of Radio Transmitter."

To carry on his experiments, it was logical that Hanna should find his way into the Westinghouse Graduate Students' Course immediately after graduation. There he received varied practical shop training. Then, in less than a year, he was busily at work on his favored radio subject at the Westinghouse Research Laboratories.

One of his accomplishments has been the development of an improved microphone. He has introduced the electrodynamic principle, in place of the condenser-transmitter type of microphone in earlier use. Hanna's development assures good quality of speech and music with greater continuity of operation than other types, because of its ruggedness and sensitivity.

For this inventive spirit and its result in microphones, Hanna's alma mater in 1926 honored him with a degree of Electrical Engineer to go with his Bachelor of Science degree of four years earlier.

And these are studies which still go on. There is no end to progress. It is because Westinghouse offers both facilities and appreciation for practical study that Research Engineers find satisfying careers in the Company's laboratories.

"What's the future with a large organization?" That is what college men want to know, first of all. The question is best answered by the accomplishments of others with similar training and like opportunities. This is one of a series of advertisements portraying the progress at Westinghouse of typical college graduates, off the campus some five —eight— ten years.

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The Sidewalks of New York

HAVE become for most of us that very short space between going up and going down. We do not travel much on the surface these days. If our minds were a reflection of our trip through a modern city, we should be at once the most profound and the most ethereal race in the world.

The escalator and elevator carry us from the subway to the surface, from the surface to the elevated subway. The baggage hoist lifts our trunks from level to level. We enter a building and mount to the fiftieth story. Indeed, we have almost abandoned the horizontal, and the force of gravity seems just a bit old fashioned. The Otis Elevator Company has placed at our disposal an entirely new direction.

THE OTIS ELEVATOR must accept a great deal of the responsibility for the crowding of New York's sidewalks in the congested district. This seems fanciful but nevertheless it is true. Newspapers and magazines continually deplore the increasingly over-crowded condition of these sidewalks, due to the ever-increasing height of buildings. If it were not for the developments in the elevator industry made by the Otis Elevator Company as a pioneer, it would not have been possible to erect buildings of the stupendous heights which are now in vogue. It is the high speed Gearless Elevator, now culminating in the 800 ft. speed automatic signal control elevator, which has made the fiftieth floor almost as available in point of time as the twentieth floor, and that has, therefore, made it feasible to pile office on office high into the air.

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World

At Forty

"At Forty" the housewife in some sections of Europe wears a black bonnet to signify the end of her youth. A quaint custom—you say—but it usually signifies a fact. Heavy tasks, indoors and out, have made her old—at forty.

Of all the uses of electricity in America, the most important are those which release the woman from physical drudgery. Electricity carries water, washes clothes, cleans carpets, cooks the family's food—better and quicker than could be done by hand.

A trip to town or an hour's rest in the afternoon pays a woman dividends in good health "at forty years." And what is *youth* but that?

Men and women who have had the benefit of college training and college life have learned to place the proper value upon rest and recreation. They appreciate the relief afforded by electricity.

Upon great generators which send out current to light the homes and carry the burdens of millions, you will find the G-E monogram. Upon industrial motors, on electric railway trains—wherever quality and unfailing performance are first essentials—the G-E monogram will be found.

A series of G-E advertisements showing what electricity is doing in many fields will be sent on request. Ask for booklet GEK-1.

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